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13 November 1998

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BY: JRM

Mr. John Munn
California Department of Forestry
1416 Ninth St.
Sacramento, CA 95814

Dear Mr. Munn:

Over the past several months we have received numerous requests from individual members of the public and public organizations to provide an independent scientific review of the Pacific Lumber Company's Habitat Conservation Plan / Sustained Yield Plan and the associated Environmental Impact Statement and Review for the "Headwaters Agreement". Enclosed is that review. It is based on our own research as well as on our knowledge of current research conducted by other scientists in our area of expertise. We have focused our comments on aquatic, riparian, and late seral habitats and the amphibian and reptile species associated with them. We hope these comments will be helpful to you in assessing the HCP/SYP and EIS/EIR.

Sincerely,

Hartwell H. Welsh

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Research Wildlife Ecologist / Herpetologist

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COMMENTS ON THE PALCO HCP/SYP AND EIS/EIR WITH REGARD TO THE MAINTENANCE OF RIPARIAN, AQUATIC, AND LATE SERAL ECOSYSTEMS AND THEIR ASSOCIATED AMPHIBIAN AND REPTILE SPECIES

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Although scientists from many disciplines have conducted research in the redwood forest region, there are few comprehensive interdisciplinary studies (but see Ziemer 1998) and no region-wide overview or synthesis of the unique nature of aquatic systems in the redwood ecoregion has been published. Fortunately, however, a large body of applicable science exists on riparian and aquatic systems and the relationships between geomorphological, hydrologic, and biotic processes in the Pacific Northwest, with many of these studies inclusive of the redwood ecoregion (e.g., Meehan 1991, Spence et al. 1996, National Research Council 1996, Stouder et al. 1997). Collectively these studies agree that "...the retention, restoration, and protection of aquatic and riparian processes and landforms that contribute habitat elements to streams and promote good habitat conditions for fish and other aquatic and riparian-dependent organisms..." (Sedell et al. 1994) are essential to maintaining healthy populations of these resources across the landscape in perpetuity. In light of this science, we examine the validity of the conclusions and proposals presented by Pacific Lumber Company (PALCO) for managing riparian and aquatic resources in their habitat conservation plans (HCP/SYP) and the associated environmental impact statement (EIS/EIR) prepared by the U. S. Fish and Wildlife Service and the National Marine Fisheries Service. We also comment on the issue of late-seral forest habitat, and the implications of herbicide use, as proposed in the HCP/SYP and in the EIS/EIR.

Our approach here is to first discuss in some detail, based on scientific literature, what comprises a healthy, functioning riparian/aquatic ecosystem in the Pacific Northwest ecoregion. We have done this to provide the appropriate frame of reference against which to measure proposed management actions. This perspective is also critical to understanding the ecological and evolutionary context within which the species addressed in the HCP/SYP and EIS/EIR have evolved over the millennia. Without this understanding of their place within the ecosystem, there can be little hope of designing effective strategies to maintain these species on the landscape. Here we make reference to critical riparian and aquatic processes, and the spatial and temporal dynamics within which they operate. We then briefly describe the documented effects of logging on these processes and dynamics. In this context we address how well both the California Department of Forestry (CDF) Forest Practice Rules and the modifications to those rules, as proposed in the HCP/SYP, currently address or may ameliorate those effects, and whether or not these rules or proposals serve to maintain a healthy, functioning riparian/aquatic ecosystem. We then provide a review of the HCP/SYP species conservation plans for five riparian and/or aquatic amphibian and reptile species, and analyze the probable effects of the HCP/SYP, and the various EIS/EIR alternatives. Concurrently, we offer some suggestions on how viable populations of these species might best be maintained on the PALCO landscape.

Stream Ecosystem Processes in Pristine Watersheds

The Role of Riparian Vegetation and Large Woody Debris (LWD)

It is important to recognize the dominant role of riparian plants in stream ecosytems. Terrestrial plants provide shade, regulate microclimates, and contribute both large wood pieces that add habitat complexity and small organic materials that serve as food for aquatic organisms. They also stabilize stream banks, control sediment inputs from surface erosion, and regulate nutrient and pollutant inputs (Fig. 1; Naiman and Decamps 1997; Spence et al. 1996; Naiman et al. 1992; and Gregory et al. 1991). Redwood trees by virtue of their size, age, and resistance to fire, floods, and decomposition play a central role in shaping the physical and chemical conditions within the aquatic zone and, thereby, strongly affect the aquatic community. As the world's tallest trees, redwoods cast long shadows and shade even wide streams. Large redwoods entering streams due to blowdown, bank undercutting, or mass wasting can remain for centuries, functioning as stream features that rival bedrock sills or outcrops in regulating channel processes. Therefore, historical harvesting of redwoods throughout most of the region, with much of the early harvest taking place along streams, has significantly altered stream ecosystems. Current harvesting is often still focused around streams because trees grow larger and more quickly there.

Stream habitats are created and modified by changes in the delivery and routing of five watershed elements: water, sediments, nutrients, heat, and woody debris (Table 1; Naiman et al. 1992). Pristine watersheds have stream channels with a complex array of hydraulic conditions (pools, riffles, alcoves, side channels, single and multiple channel sections), substrate sizes, and accumulations of wood and other organic matter. Large woody debris (LWD) consists of large logs that fall into stream channels, either from natural tree death, wind throw, or bank failure,

Figure 1. Energy sources for energy-flow pathways in, and the trophic structure of, woodland stream ecosystems. Deciduous leaves, photosynthesis by diatoms, and dissolved organic matter in groundwater are major energy sources. Genera that typify consumer functional groups are the shredders *Pteronacys* (above), *Tipula*, and *Pycnopsyche*; the collectors *Stenonema* (left) and *Simulium*; the scraper *Glossoma*; and the predators *Nigronia* (lower right). *Cottus*, and *Salmo* (left). Litter microbes are characterized by hyphomycetes fungi. The dashed arrow indicates infrequent exchange. Organisms are not drawn to scale. From Murphy and Meehan (1991) as adapted from Cummins (1974).

Table 1. Riparian forests: important ecological elements and their functions for aquatic and riparian vertebrate and invertebrate communities (From Roelofs and Welsh, in review).

	Element						
Locations and Functions	Large Woody debris	Organic litter	Roots	Substrate	Overstory vegetation	Understory vegetation	Soil
Stream Channel:							
Provides breeding, feeding and shelter habitat for many species	X	X		X			
Controls aquatic habitat dynamics	X						
Contributes to formation of islands and floodplains	X						
Sorts, routes and retains substrates	X						
Filters and stores sediments and organic material	X						
Increases primary and secondary production		X					
Self sorts and provides habitat heterogeneity				X			
Stream Banks:							
Provides breeding, feeding and shelter habitat for many species	X		X	X			X
Stabilizes stream banks	X		X				
Provides coarse woody debris to channel	X						
Provides substrate to channel				X			

Table 1. (cont'd)

Locations and Functions	Element						
	Large woody debris	Organic litter	Roots	Substrate	Overstory vegetation	Understory vegetation	Soil
Floodplain:							
Provides breeding, feeding and shelter habitat for riparian species	X	X		X	X	X	X
Regulates air temperature, humidity, and solar penetration					X	X	
Provides suitable microclimatic conditions	X	X		X			
Provides woody debris to channel	X				X		
Provides organic litter to channel					X	X	
Retards movement of coarse woody debris					X	X	
Filters sediment	X	X		X	X	X	
Dissipates water energy	X	X		X	X	X	
Adjacent Hillslope:							
Provides breeding, feeding, and shelter habitat for many species					X	X	
Regulates air temperature, humidity, and solar penetration					X	X	
Provides woody debris to floodplain and channel	X				X		
Provides organic litter to floodplain and channel		X			X	X	
Protects riparian forest from effects of wind					X	X	

Table 1. (cont'd)

Locations and Functions		Element: Large woody debris	Organic litter	Roots	Substrate	Overstory vegetation	Understory vegetation	Soil
Adjacent Hillslope (cont.):								
Provides recruitment source to floodplain and channel					X			
Filters sediment	X	X				X	X	
Dissipates water energy	X	X				X	X	X

which then plays an important role in structuring stream habitats (Table 1). In the redwood ecoregion large redwood logs can play a dominant role in stream processes and channel complexity (Keller et al. 1995). Keller et al. (1995) stated that in headwater streams flowing through old-growth redwoods, nearly all the pools may be either directly formed by, or significantly influenced by large organic debris (i.e. logs). Welsh and Ollivier (*unpublished data*) reported an average of 55 logs greater than 20 inches DBH per kilometer (standard deviation = 11) for ten pristine streams in old-growth redwood in Prairie Creek Redwoods State Park (Humboldt County); 99% of which were conifer logs, primarily redwood. Keller et al. (1995) aged 30 individual logs in the Prairie Creek Basin and found that about half of them had been in the stream for over 100 years, some in excess of 200 years. In coastal Oregon streams Andrus (1988) found that 70 percent of pools greater than 1 cubic meter in volume were formed by wood. He also noted that conifers are markedly more decay resistant than hardwoods and that redwood and cedar outlast Douglas-fir and hemlock in streams. Neapolitan (1998) compared present day log volumes in an historically (1864 to 1904) clearcut and splash dam logged second-growth coastal redwood stream (North Fork of Casper Creek) (24 kg m^2) with nine similar streams in old-growth redwood (49 to 268 kg m^2). Napolitano (1998) noted that the difference in the abundance of large logs between Caspar Creek and the old-growth streams resulted in lasting channel changes, including channel incision, simplification of form, and reduction in sediment storage capability. In a natural system with intact riparian forests a large proportion of these logs would enter streams from the highest channels in the stream network (CDF Class II & III channels) during large storm events (Sedell et al. 1988). In fact, because of the role they play in providing LWD and a variety of sediment types, headwater stream channels

(CDF Class II and III) mainly determine the type and quality of downstream fish habitat (Sedell et al. 1988). Research fisheries biologist G. Reeves stated it thusly, "reaches that are themselves inhospitable to salmonids may contribute to the maintenance of salmonid populations downstream." (Reid 1998:482).

The River Continuum Concept

The river continuum concept (Fig. 2; Vannote et al. 1980; Minshall et al. 1983; Minshall et al. 1985, Minshall et al. 1992) indicates that natural stream communities undergo predictable changes from headwater areas to lower elevations in response to fluvial processes; changes in the relative contributions of riparian versus aquatic primary producers (plants); and the size and type of organic material being transported from upstream areas. Small, headwater streams have steep gradients, confined channels and cool temperatures when adequately shaded by riparian vegetation. Consequently, they obtain most of their organic material in the form of leaves, needles, branches and other plant parts from the riparian zone rather than from primary producers within the stream. Farther down the river continuum, stream channels are less confined and have more extensive flood plains. Instream primary production increases in response to greater light penetration. Daily temperature fluctuations in these lower stream sections also are more pronounced because of increased exposure to solar warming (Beschta et al. 1987). Historically, old-growth redwoods in the riparian zone of intermediate-sized streams extensively shaded streams and limited both temperature gains and primary production (Table 1). Large woody debris (LWD) input also changes along the stream continuum, with smaller channels (e.g., CDF Class II & III) contributing more LWD to the stream network than larger channels (e.g., CDF Class I & II) (Sedell et al. 1988).

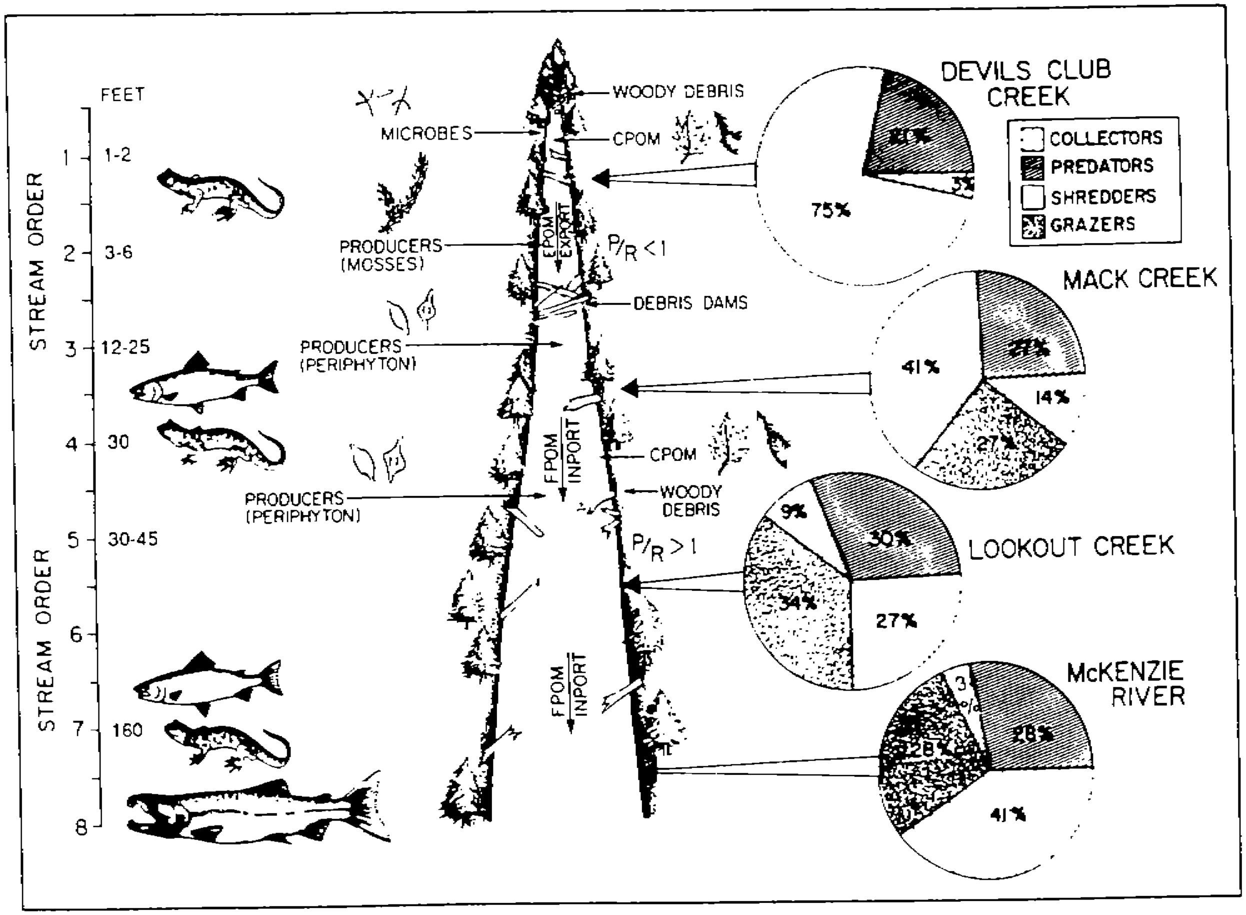

Figure 2. The river continuum concept (adapted from Vannote, et. al. 1980). An example showing stream width, dominant predators, producer groups, production (P) to respirations (R) ratios, importance of wood, and proportions of invertebrate functional groups. CPOM = course particulate organic matter, FPOM = fine particulate organic matter (from Sedell et. al. 1988).

Biological communities in streams are highly complex and dynamic entities comprised of hundreds of plant and animal species structured and organized in response to physical, chemical, and biological interactions. Interactions between the major abiotic factors (solar energy, climate, geology, geomorphology, and hydrology) provide the physical environment (Bencala 1984; Boulton and Lake 1991) that influences the species composition of the community. Biological interactions between organisms include food web linkages (i.e., herbivory, predator-prey), competition, mutualism, and disease- or parasite-host relationships (Spence et al. 1996). Stream communities are by nature highly dynamic, responding continually to changes in environmental conditions both temporally and spatially. The river continuum concept (Vannote et al. 1980) predicts a systematic change in consumer functional groups from headwater areas downstream (Fig. 2). Small streams are dominated by invertebrates that process riparian litter and its residues (shredders and collectors). Intermediate sized streams have more "scrapers" in response to increased periphyton growth due to greater light availability. Further downstream, "collectors" (filter feeders) predominate using the fine particulate organics that upstream communities produce and fail to retain. Predators, of course, are present all along the continuum. The carcasses of spawned out anadromous fish are an important component of the nutrient cycle in stream ecosystems, providing inputs from the marine environment (e.g., Cederholm et al. 1989).

Energy flow within stream communities is often represented by the feeding relationships of various functional groups (Fig. 2). The base of the food web is provided by plants, either from the riparian zone (allochthonous material) or instream primary producers (autochthonous material) such as algae, mosses, and rooted aquatic vascular plants. The allochthonous material is broken down biologically by bacteria and fungi, and physically by abrasion (Cummins 1974).

Leaves and needles are degraded more quickly (days to weeks) than larger materials such as branches and tree boles (years to centuries) and provide most of the useable organic matter in woodland streams (Murphy and Meehan 1991). The functional group termed "shredders" consume pieces of this organic material, derive most of their energy from digesting the associated bacteria and fungi, and produce fecal pellets. This feeding behavior converts coarse particulate organic matter (plant material > 1 mm diameter) to fine particulate organic matter (0.5 mm - 1 mm diameter). These fine particles are again colonized by bacteria and fungi and serve as the energy source for a functional group termed "collectors" (filter feeders). The functional group "scrapers" rasp algae or microbes from mineral or wood substrates, again producing fine particulate organic material that is consumed by collectors. The last functional group, "predators," feed on the other three groups, plus terrestrial organisms entering from the riparian zone (i.e. insects and spiders) and each other. Most aquatic and semi-aquatic vertebrates are predators, although some fish (i.e., California roach and Sacramento sucker) eat significant amounts of plant material (Moyle 1976). Most of these small stream organisms live in the interstices of the streambed substrate during part or all of their life cycle. This complex stream food web, vital to all stream organisms, has a distinct longitudinal component (Fig. 2) that is disturbed and disrupted by logging impacts, especially at the upper ends of the channel network.

Disturbance

The role of disturbance in structuring stream communities has been a primary focus of aquatic ecology for the past decade (Spence et al. 1996; Wootton et al. 1996; Reeves et al. 1995; Townsend 1989; Resh et al. 1988; Stanford and Ward 1992). Some changes are cyclic such as seasonal changes in solar radiation, temperature, discharge, and leaf fall. Less predictable but longer-lasting disturbance events like major floods, fires, mass-wasting events, and extreme winds that lead to windfall in the riparian zone, can influence the physical environment, and thus the biological community, for decades to centuries. Both natural disturbances (i.e., floods, fires, mass wasting caused by previous events and earthquakes) and anthropogenic activities (i.e., timber harvest, agriculture, mining, urban development, dams, and bank channelization) change the riparian communities associated with stream systems (Gregory et al. 1989; Schlosser 1991; Sedell et al. 1997; Frissell et al. 1997). Reeves et al. (1993) found that in coastal Oregon, the species diversity of salmonid fish assemblages was reduced in those watersheds with greater than 25% of the old-growth forest of the basin harvested. While natural disturbance events tend to be infrequent and cause large, localized changes to stream systems (pulse or stochastic events), the human-caused changes are often more frequent and span larger regions of the landscape (press or deterministic events) (Yount and Niemi 1990). Within the redwood region, stream communities are shaped both by past natural disturbance events and a pervasive legacy of past and present human activities. Timber harvesting, especially at the scale currently practiced on the North Coast of California, and on PALCO lands, represents an extreme disturbance to natural ecosystem processes, and is occurring on a scale that has altered much of the landscape beyond any natural disturbance it has experienced before (see Reeves et al. 1995). This level of disturbance is now of such magnitiude, and on such a scale, that it is unique in history, and, as indicated by the extensive loss of native biota, especially aquatic and riparian forms like the many unique salmonid fish stocks in decline in Northwestern California, it may already be irreparable for many of these species (Stouder et al. 1997).

Changes in Stream Ecosystem Processes Resulting from Timber Harvesting

The spatial and temporal scales of continuous timber harvest within the redwood region, has led to widespread and persistent changes in stream conditions (Table 2). The most pronounced change is the absence of, or reduction in, large trees within and adjacent to stream channels. In terms of potential long-term effects on aquatic biota and their habitats, one of the most significant modifications of riparian conditions from logging evidenced in a second growth redwood dominated coastal watershed (Caspar Creek; see Ziemer 1998a), was the alteration of the large woody debris (LWD) regime (Lisle and Napolitano 1998). The initial increase of LWD from blow-down in the riparian buffers increased habitat heterogeneity by storing sediments and forming pools (Nakamoto 1998). However, the available size and species composition of this LWD, because of historical logging in the 19th century (Napolitano 1998), meant the long term result would be overall less favorable habitat conditions for aquatic species as the small, now hardwood-dominated LWD (which decays much faster then conifers) decays quickly and input rates from depleted riparian sources in adjacent clearcuts and buffer zones decline (Lisle and Napolitano 1998; see also Reid and Hilton 1998). It is likely that the changes in stream conditions that have occurred in the Caspar Creek watershed (Jackson State Forest, Mendocino Co., California) are even more pronounced on PALCO lands given the relatively more intense harvest regime that is underway on that landscape compared with Caspar Creek.

Riparian forests on heavily logged landscapes are often dominated by deciduous trees (i.e., alders [*Alnus* spp.] , big leaf maple [*Acer macrophyllum*], and willows [*Salix* spp.]), with a lesser component of second or third growth conifers. Red alder (*Alnus rubra)* often dominates the riparian zones of coastal streams in clearcut watersheds (Dahm 1981). Lacking large, and

Table 2. Influences of timber harvest on physical characteristics of stream environments, potential changes in habitat quality, and resultant consequences for salmonid and amphibian growth and survival. Modified from Hicks et al. (1991).

Forest practice	Potential change in physical stream environment	Potential change in quality of habitat	Potential consequences for growth and survival
Timber harvest from streamside areas	Increased incident solar radiation	Increased stream temperature; higher light levels; increased autotrophic production	Reduced growth efficiency; increased susceptibility to disease; increased food production; changes in growth rate and age at smolting
	Decreased supply of large woody debris	Reduced cover; loss of pool habitat; reduced protection from peak flows; reduced storage of gravel and organic matter; loss of hydraulic complexity	Increased vulnerability to predation; lower winter survival; reduced carrying capacity; less spawning gravel; reduced food production; loss of species diversity
	Addition of logging slash (needles, bark, branches)	Short-term increase in dissolved oxygen demand; increased amount of fine particulate organic matter; increased cover	Reduced spawning success; short-term increase in food production; increased survival of juveniles
	Erosion of streambanks	Loss of cover along edge of channel; increased stream width; reduced depth	Increased vulnerability to predation; increased carrying capacity for age-0 fish, but reduced carrying capacity for age-1 and older fish
		Increased fine sediment in spawning gravels and food production areas	Reduced spawning success; reduced food supply

Table 2. cont.

Forest practice	Potential change in physical stream environment	Potential change in quality of habitat	Potential consequences for growth and survival
Timber harvest from hillslopes; forest roads	Altered streamflow regime	Short-term increase in streamflows during summer	Short-term increase in survival
		Increased severity of of some peak flow events	Embryo mortality caused by bedload movement
	Accelerated surface erosion and mass wasting	Increased fine sediment in stream gravels	Reduced spawning success; reduced food abundance; loss of winter hiding space
		Increased supply of coarse sediment	Increased or decreased rearing capacity
		Increased frequency of debris torrents; loss of instream cover in the torrent track; improved cover in some debris jams	Blockage to migrations; reduced survival in the torrent track; improved winter habitat in some torrent deposits
	Increased nutrient runoff	Elevated nutrient levels in streams	Increased food production
	Increased number of road crossings	Physical obstructions in stream channel input of fine sediment from road surfaces	Restriction of upstream movement; reduced feeding efficiency
Scarification and slash burning (Preparation of soil for reforestation)	Increased nutrient runoff	Short-term elevation of nutrient levels of streams	Temporary increase in food production
	Inputs of fine inorganic and organic matter	Increased fine sediment in spawning gravels and food production areas; short-term increase in dissolved oxygen demand	Reduced spawning success

well-distributed rot-resistent conifer wood, and with excess sediment filling the streambed, many streams on PALCO lands have fewer and shallower pools, and a less diverse array of physical conditions than reference streams in pristine settings (T. Roelofs, *pers. comm.*). The physical habitat conditions in streams comprise the ecological context for organisms that have evolved there (Holt and Gaines 1992, Southwood 1977). Stream communities in logged versus unlogged streams are often different because the former have unsuitable habitat for many aquatic organisms. For example, many small, non-fish bearing streams that were logged during the past 40 years (even those subject to current forest practice rules), are covered by five to fifteen feet of debris and sediments (H. Welsh, *pers. obs.*). These buried stream channels frequently flow sub-surface for hundreds of feet, providing little or no habitat for many native aquatic organisms. Lewis (1998) found that while changes in the forest practice rules between the 1970's and the 1990's reduced the amount of suspended sediment in Caspar Creek, logged areas still accounted for 89% more sediment than unlogged areas. He noted much of this sediment appeared to be mobilized from the unbuffered Class III watercourses (Lewis 1998).

Critical PALCO and CDF Inadequacies

Stream Classification and Its Problems

The greatest single scientific shortcoming in the PALCO HCP/SYP, from the perspective of riparian and aquatic resources, is its total reliance on the conceptual approach to stream buffer protections used in the CDF stream classification system. The CDF system fails to recognize that a stream ecosystem and its vital processes are a functional continuum (Fig. 2). The CDF system establishes differential protection measures along the stream continuum based upon two factors, permanence of surface water and the presence of fish and other aquatic life. In reality, HW-1 the presence of surface water has become the functional equivalent for the presence of aquatic life. Because headwater areas may have ephemeral surface flow, though perennial subsurface flow, and are not fish-bearing, these regions receive the least protection in terms of canopy retention, buffer zone width, and LWD retention. Perennial fish-bearing streams or rivers, under the CDF system, have the highest standards for canopy and LWD retention and buffer zone width. The lack of recognition of the importance of headwater and other small streams for temperature amelioration, LWD recruitment, etc., renders the CDF system ineffective for maintenance of ecosystem processes. There is no basis in science for their different buffer width designations. Rather it reflects a bias in human valuation for game fishes over other riparian and aquatic biota, and an ignorance of the stream continuum and the requirements of a healthy functioning stream ecosystem upon which these fish depend. If the appropriate science were considered, the formulation for buffer widths would in fact be reversed. That is, wider buffers would be provided on headwaters (CDF Class II & III or 1st - 3rd order streams [Strahler 1957]), because they (1): tend to be transport reaches that provide important structural components such as LWD, (2): contribute a mixture of sorted coarse sediments of varying sizes downstream, and (3): are generally the source of the coldest waters. These headwater channels are also potentially the greatest source of fine sediments that can congest streambed interstices. Sediment-free interstices downstream are required for successful spawning by salmonid fishes, and shelter the early life stages of both stream macroinvertebrates and several species of stream amphibians. Consequently, headwater channels need wider buffer widths than exist under current CDF rules or than are proposed in the HCP/SYP, to filter out fine sediment run-off from the generally steeper terrain in which these channels are typically embedded.

HW-1 CONT

HW-2

From the perspective of some of the stream biota, the headwaters are important areas where selected organisms thrive in the absence of fish predators. Some of these species appear to require areas with little or no predation in order to maintain viable populations on the landscape (e.g., see torrent salamander section below). Among such life forms are several amphibians species which require both aquatic and terrestrial environments in which to carry out their complex biphasic (aquatic & terrestrial) life histories. Their requirement for equitable terrestrial environments means they need cool, moist, stable microclimates in riparian forests alongside streams, where the adult life stages hide, forage, and seek mates. As currently proposed, the 10 foot (interim) to 30 foot 'no harvest' zone alongside Class II streams (Vol. IV, Part D, p. 30-41), may be mostly 'edge' habitat (Laurance and Yensen 1990), and lacks sufficient 'interior core' areas where terrestrial microclimates would be adequately ameliorated and stabilized (Yahner 1988, Saunders et al. 1991, Brosofske et al. 1997). Based on recent research, no-harvest buffers of 30 - 60 meters (~ 90 - 180 feet) would be required to maintain suitable streamside and aquatic conditions for several cold-temperate adapted amphibian species (Brosofske et al. 1997, Ledwith 1996, Welsh and Hodgson, *unpubl data*).

HW-2 CONT.

By ignoring these ecological processes and functions, the CDF system establishes and maintains a negative feedback situation whereby downstream habitats can be progressively and continuously degraded due to unprotected headwaters (Class III channels) upstream. The Mattole River Basin, and many other severely degraded watersheds on the North Coast, attest to this process of serial magnification of negative cumulative impacts due to poor timber harvest practices (Mattole Sensitive Watershed Group 1996, MRC 1989). The result is a cascading disaster for aquatic and riparian resources where even portions of the stream that may intially support fish (Class I stream reaches) shrink and retreat with each harvest re-entry in a watershed, as streams are changed from Class I to II and II to III, until there are fewer and shorter portions of a stream system that can support cold-water adapted fish or amphibians. We will have more to say about the effects of this regulatory oversight and its effects on individual species in the Species Reviews below. HW-2 CONT.

Riparian Vegetation and Large Woody Debris

The majority of LWD in a healthy system comes into the system in the headwaters and upper tributaries of the stream network, with less contributed along the larger, lower stream reaches (Maser et al. 1988). Adequate provisions in the PALCO HCP/SYP for this important ecosystem component are noticably missing for Class III, and insufficient for Class II streams. No where in the HCP/SYP can we find mention of designated (dedicated) leave trees in the riparian management zone (RMZ's) that might eventually contribute LWD greater than 24" to the Class II stream networks. It would appear that under this HCP/SYP, with the formula theoretically provided to maintain a mix of tree size classes in the RMZ's, that the reality is that the largest trees can (and probably will) be removed from the RMZ, as long as the 240 and 300 foot basal area requirements are met. Without provisions, based on some number of specific, and well distributed, dedicated trees for recruitment of LWD, especially in size class 5 (>24"DBH; Mayer and Laudenslayer 1988), along the entire stream continuum, this critically important structural element (Table 1; Sedell et al. 1988) will continue to be lacking from the important upper reaches of the stream networks of the PALCO landscape. HW-3

Riparian and Aquatic Species Reviews

Southern Torrent Salamander

Natural History

The southern torrent salamander (*Rhyacotriton variegatus*) is a headwater specialist, which breeds in springheads and other emergent water sources (Nussbaum 1969). It requires cold, clear, shallow water flowing over clean, coarse streambed substrates (Welsh and Lind 1996). In the interior parts of its range in California, it is closely associated with late seral forests (Welsh 1990). The PALCO HCP/SYP states that the species ranges up to 3,900 ft, but recent evidence indicates that it can be found to near 5000 ft. in elevation (L. Diller, *pers. comm.*).

The authors of the PALCO HCP/SYP, citing Diller and Wallace (1996) argued that torrent salamander distributions on PALCO lands are determined by the gradient of the stream channel (Vol. IV, Part E, p. 2). Their argument is that stream channels with steeper gradients generate higher water velocities which tend to flush the fine sediments from the coarse substrates and thus create better microhabitat for this salamander. While we agree with the general process model they present (i.e. flushed coarse substrates create better microhabitat), we disagree with the interpretation that steeper channels are required to support this salamander. This may be the case on commercial timberlands (Diller and Wallace 1996), where much of the suitable microhabitat for this salamander along streams with gentle gradients has been compromised by excessive fine sediments filling the streambed interstices. However, we sampled ten streams in Prairie Creek Redwoods State Park (range of gradients = 2-14%, mean = 5.3%, n = 26 habitat units) and found no statistically significant relationship between channel gradient and salamander presence ($r = -0.213$, $p = .295$; Welsh and Ollivier, *unpubl. data*). HW-4

Baseline Condition

The PLHCP/SYP states that southern torrent salamanders are "widely distributed in suitable habitat" on PALCO lands (Vol. IV, Part E, p. 2). However, distributions and densities on managed, redwood timberlands have never been compared with those of nearby pristine parklands (cf. Diller and Wallace 1996). Density data for individual populations of this species, as well as data on the spatial distributions of these populations (metapopulation structure), on commercial timberlands need to be compared with data from reference landscapes to examine how the torrent salamander has fared under forest management on PALCO lands and other private timberlands. We lacked true density data for torrent salamanders from PALCO lands that could be used for such a comparison. However, we were able to compare salamander captures per unit effort, a measure of relative abundance, from PALCO lands (Wroble and Waters 1989) with similar data from reference sites (i.e. pristine watersheds with the same forest type and similar parent geology to that of PALCO lands) at Prairie Creek Redwoods State Park (Welsh and Ollivier, *unpubl. data*). Wroble and Waters (1989) reported an average of 0.052 (standard deviation [S.D.]= 0.092) southern torrent salamanders/hour of search time from seventeen drainages on PALCO lands. We found an average of 0.724 (S.D.=0.786) southern torrent salamanders per hour in ten streams sampled at Prairie Creek Redwoods State Park (Welsh and Ollivier, *unpubl. data*). This is a remarkable difference, that is highly statistically significant (Mann-Whitney test; $Z = 2.93$, $p = 0.003$), and indicates very low numbers of torrent salamanders on PALCO lands. This result indicates, based on their statement that the species is "widely distributed in suitable habitat" (Vol. IV, Part E, p. 2), that suitable habitat is seriously lacking. HW-5

Wroble and Waters (1989), and the authors of the HCP/SYP, maintain that the low abundance of torrent salamanders is the result of the geomorphology found on PALCO lands, an unconsolidated geology that can yield abundant fine sediments that make the streambed substrates unsuitable for torrent salamanders. This argument fails to be convincing, however, because streams with abundant populations of southern torrent salamanders in Prairie Creek Redwoods State Park also dissect unconsolidated geology. In order to test the validity of this hypothesis, we tested the assumption that parent geology influences the occurrence of populations of this salamander using data from all localities from across the range in northwestern California (n = 83 sites; Redwood Sciences Laboratory, *unpubl. data*). After classifying all 83 localities on the basis of parent geology, our analysis indicated that the presence of torrent salamanders was in fact independent of parent geology (consolidated vs. unconsolidated) ($X^2 = 0.153$, $p = 0.696$; Welsh and Ollivier, *unpubl. data*). HW-5 CONT.

<u>Activities With Potential for Impacts</u>

Timber harvesting is the primary activity of concern for the southern torrent salamander. Several recent studies have demonstrated that this species is less abundant and often absent from managed forestlands (Welsh 1990, Welsh and Lind 1996). The habitat components necessary to sustain populations include: low water temperatures (6.5-15 °C), low sediment levels (3-47% embededness) and cool, moist, riparian environments (Welsh and Lind 1996). Water temperatures are likely the most critical component. Torrent salamanders experience thermal stress at temperatures above 17.2 °C (Welsh and Lind 1996) (see Stream Temperature Regimes section below). In the Mattole River basin (an area with extensive PALCO holdings), many streams currently exceed this value during the summer and temperature fluctuations in managed streams are much greater than in unmanaged late seral streams (Fig. 3). In one instance a stream HW-6

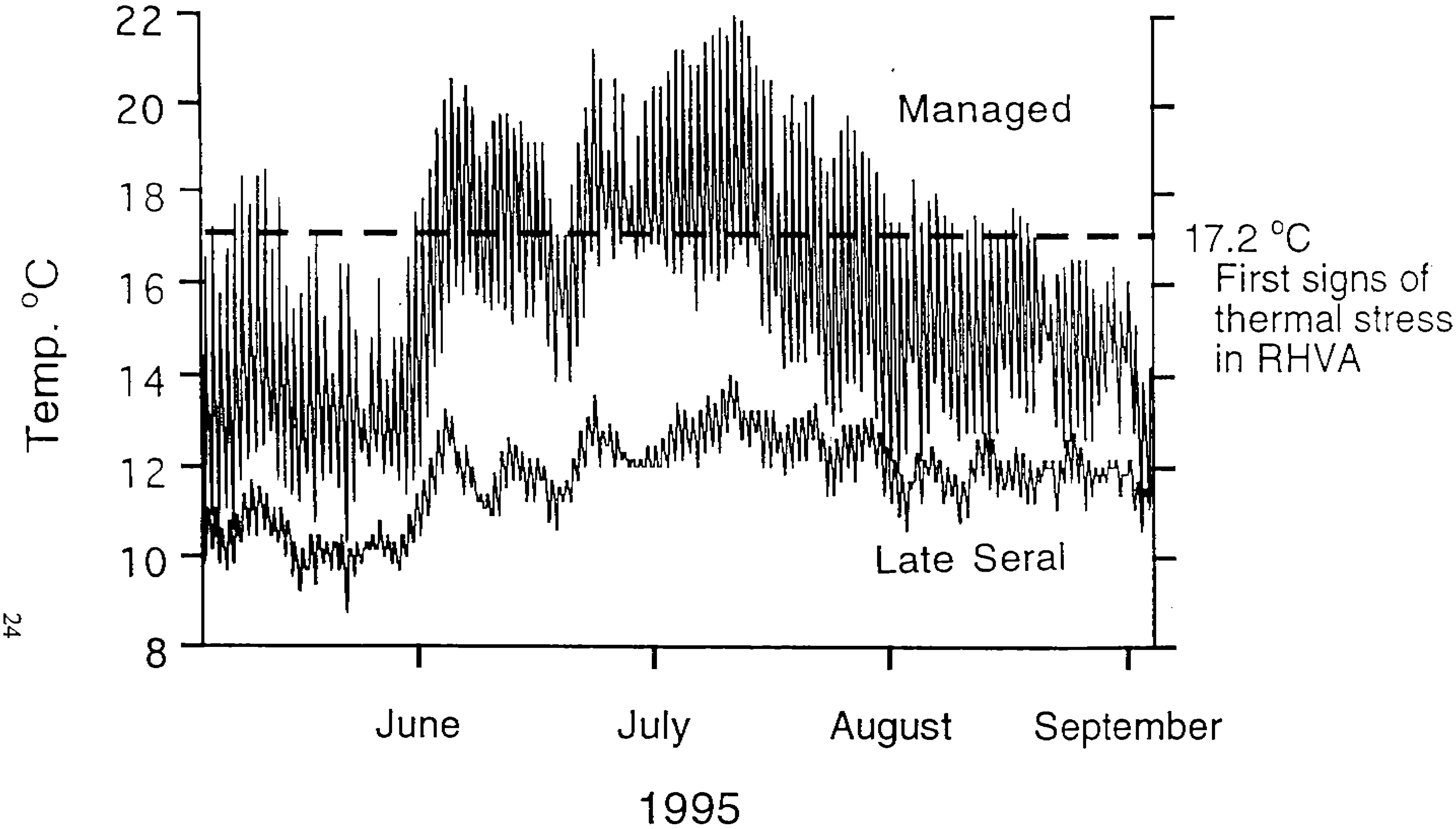

Figure 3. Diel cycle (twenty-four hour) water temperature records for two streams in the Mattole River basin; one managed and one un-managed (late seral) during the summer of 1995 (Welsh and Hodgson, *unpublished data*). The dashed line represents the thermal stress level for the southern torrent salamander (*Rhyacotriton variegatus*) based on laboratory data (Welsh and Lind 1996).

that was documented to have torrent salamanders as recently as the 1960's (U. C. Berkeley, Museum of Vertebrate Zoology catalog numbers 187392-187394) appears to no longer support this species based on our intensive sampling annually over the past four years. This heavily logged basin now has water temperatures that regularly exceed the thermal stress level of the torrent salamander (Fig. 3).

Although the southern torrent salamander may be more tolerant of stream canopy removal in the marine-influenced coastal, redwood zone (Diller and Wallace 1996), declines on some commercial timberlands may be undetected because the mere presence of individuals at some post-harvest sites has been considered evidence of population persistence without any test of this assumption, or any examination of metapopulation structure relative to reference landscapes (see Brode 1995). A demonstration of population persistence would require evidence for successful reproduction at multiple harvested sites over several generations, and a demonstration of a functional metapopulation distributed across this harvested landscape which would involve some evidence of movement of individuals among sub-populations. Such movement would be critical to sustaining a viable network of small, isolated sub-populations of torrent salamanders on a relatively hostile landscape (consisting of mostly unsuitable habitat) over the long term (Slatkin 1987). These important landscape level considerations are described in more detail below (see "Potential Impacts of Incidental Taking"). HW-6

<u>Mitigation Measures</u>

We believe the evidence is compelling that timber management in the redwood region has substantially reduced torrent salamander populations. We also believe that the proposed management of Class II and III channels in the PALCO HCP/SYP (Vol. IV, Part D, Section 1, p. HW-9

35-38) is not likely to forestall the further decline of this species on the PALCO landscape. Retaining this species will require management of the entire channel network by buffering both Class II and III channels with sufficient riparian forest to maintain a properly functioning riparian and aquatic ecosystem with all of its essential components (Table 1). The LWD component is especially important in that it captures fine sediments, and sufficient streamside tree canopy to maintain a cool, moist riparian forest microclimate for adults, and cold water temperatures (6.5 - 15° C) for both life stages (Welsh and Lind 1996). The HCP/SYP proposes a mitigation formula for maintaining streamside forest, which meets or exceeds a habitat model presented by Welsh and Lind (1996) based on stand characteristics at sites where they found torrent salamanders (Vol. IV, Part E, p. 3). However, the HCP/SYP does not address the more critical issue of whether or not these trees will be retained (since they are not dedicated), or how the plan will assure that the juxtaposition of retained large trees will provide appropriate large woody debris to be recruited into the stream.

HW-9
CONT.

A recent study that examined riparian microclimates (air temperature and relative humidity) on sites adjacent to PALCO lands concluded that "...land managers who wish to avoid significantly altering the microclimate of a riparian zone may want to leave no-harvest buffer strips over 30 m (~100 ft) wide..." (Ledwith 1996). However, results from a similar study in Washington indicated that 30 meters may not be sufficient to stabilize all aspects of microclimate within the streamside riparian zone (Brosofske et al. 1997). Furthermore, while it is known that southern torrent salamanders will use the riparian zone (Leonard et al. 1993; H. Welsh, pers. observations), it is not known how much might be required, and when, or for what purposes the salamanders might use these streamside areas. Given that excessive heat and lack of moisture are the most likely physiological stressors on torrent salamanders (Welsh and Lind 1996), a minimum of 30 m of stable microclimate alongside headwater streams during the summer months would probably accommodate them at the most stressful time of the year, and therefore would probably support viable populations year round. However, Ledwith (1996) noted that for other riparian functions, such as restricting sediment flow and providing the delivery of large woody debris, this minimum 30 m width would need to be increased to 60 to 80 m (~200 - 275 ft) or about one site potential tree height. The PALCO HCP/SYP states that a 60 m no-harvest buffer has been suggested as the appropriate width for protection of southern torrent salamanders (Vol. IV, Part E, p. 2), yet the HCP/SYP offers only a 30 ft (approx. 10 m) no-harvest zone over the long-term and even narrower (10 ft.= approx. 3 m) in the short term for Class II streams. Even though there is an additional buffer to 100 feet, this is based on basal area only, and there is no evidence that this will produce sufficient canopy. Nor is there evidence that such a buffer zone will provide for the microclimatic conditions required by southern torrent salamanders. In fact, the evidence is quite to the contrary (Ledwith 1996, Brosofske et. al. 1997). Brosofske et. al. (1997) found that upslope soil temperature was the best predictor of water temperatures in nearby channels. Class III streams are afforded no protection (other than equipment exclusion) and thus canopy closure levels required to maintain low water temperatures (Ledwith 1996) will not be met. Under this scenario, upstream areas with intermittent water (Class III channels) will likely heat up and cause warming of downstream (Class I and II channels) habitats. HW-7 CONT.

<u>Potential Impacts of Incidental Taking</u>

The continued isolation and fragmention of headwater habitats and the minimal protections afforded these sensitive areas under current forestry rules and this HCP/SYP (Vol.

IV, Part D, p. 30-41), have significant long-term negative genetic consequences (Slatkin 1987) for torrent salamander populations on commercial forestlands. This is the case because further isolation and fragmention of headwater habitats exacerbates those constraints on gene flow already present with a highly patchy distribution of isolated subpopulations on the landscape (Welsh and Lind 1992). Torrent salamanders display some of the highest genetic diversity among geographically proximate populations ever documented for a vertebrate species (Good and Wake 1992), suggesting that fragmentation and isolation have long been a part of their evolutionary history. Movement studies (Welsh and Lind 1992) suggest that torrent salamanders are highly sedentary which could account for some of the high genetic diversity observed among populations. These natural isolating mechanisms have been greatly exaggerated by current levels of commercial timber harvesting.

There are few data that can be used to determine just how much fragmentation and isolation this species can tolerate across a landscape before going extinct, but evidence from commerical timberlands in the Mattole watershed and Mendocino County suggests that this threshold has already been reached or exceeded in these parts of the range. We compared the percent of seeps and springs with torrent salamander detections from the Mattole watershed and Mendocino County against the total number of sites sampled from throughout the range in Humboldt (north of the Mattole), Trinity, Del Norte, and western Siskiyou Counties (Fig. 4, range-wide north; Welsh et al., *unpubl. data*). We found that the percent of sites supporting salamanders on commercial timberlands, in both Mendocino County and the Mattole watershed, were significantly lower than expected when compared with the range-wide data from north of those areas (Fig. 4; Q-tests for comparisons of proportions, $p<0.05$). The important and revealing exceptions were the sites sampled within the unlogged, 8000 acre, University of California Forest Reserve near Branscomb (north central Mendocino County), and four historical localities within State Parklands along the Mendocino coast (Fig. 4). This is clear evidence that timber harvesting on commercial timberlands in the Mattole watershed and in Mendocino County, and not the proposed more extreme climate at the southern end of its range (see Brode 1995), has caused the decline of populations on these landscapes. Multi-year sampling of aquatic vertebrates from Caspar Creek in a coastal watershed on State-managed commercial timberlands (CDF's Jackson State Forest) in Mendocino County also failed to detect torrent salamanders (Nakamoto 1998), although this drainage is near the State Park sites (Fig. 4) and contains appropriate habitat. Caspar Creek was logged using splash dams in the 19th Century (Napolitano 1998) and it is quite probable that torrent salamander populations were extirpated by this highly destructive form of log transport and have failed to re-colonize in the intervening 100+ years. These population declines on surrounding lands in the southern portion of the range of this salamander, along with the fact that it is naturally subjected to greater climatic stress at the southern edge of its range (Gates 1993), means that PALCO lands are potentially critical to the survival of the species in this region.

More detailed analysis of four years of data from the Mattole River (an area with extensive PALCO holdings) provides evidence for a process of progressive habitat degradation and the associated decline of the southern torrent salamander for an entire major river basin. Aerial photos from 1947 show a watershed that was dominated by late-seral forests (MRC 1988). Available information on fish abundances in the 1940's indicates large, healthy runs of salmon, and based on the extent of contiguous late-seral forest (MRC 1988), also an abundance of

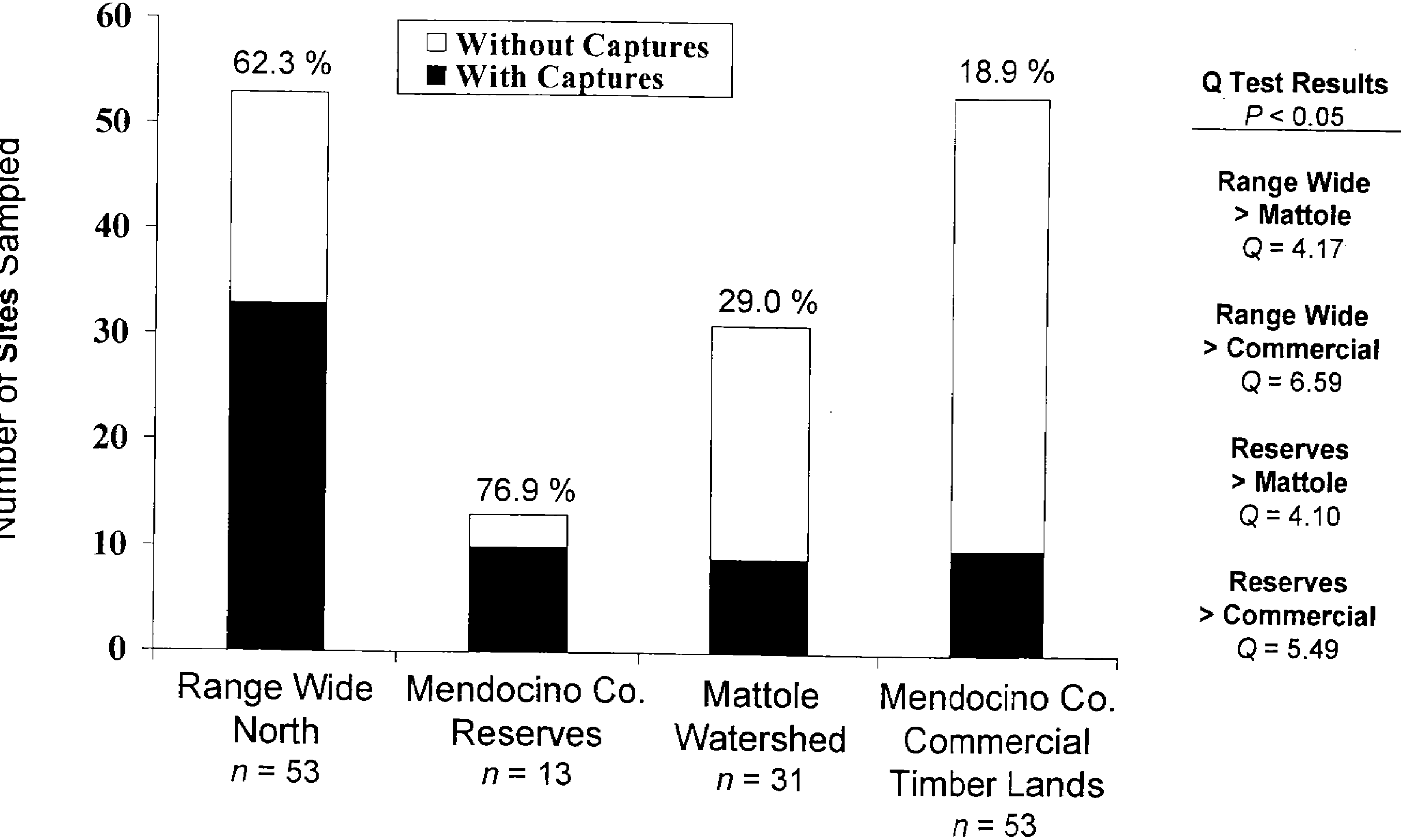

Figure 4. Presence/absence of southern torrent salamanders (*Rhyacotriton variegatus*) from areas in northern California. "Range Wide North" represents sites sampled systematically in Humboldt, Del Norte, and Trinity Counties in 1989 (Welsh and Lind 1996). "Mendocino Co. Reserves" represents surveys of State Parklands and the Angelo Preserve in the mid-1980's and early 1990's (Welsh 1990). "Mattole Watershed" represents surveys of a representative set of streams in the Mattole watershed in the mid-1990's (Welsh and Hodgson, *unpublished data*). "Mendocino Co. Commercial Timberlands" includes surveys on Louisiana-Pacific and Georgia-Pacific timberlands in the mid-1990's (J. Ambrose, pers. comm.).

associated cold-water adapted amphibians including the torrent salamander. We tested the null hypothsis that the distribution of torrent salamanders was unrelated to vegetation cover. This hypothesis was rejected, and what we found was that currently only the few remaining streams with a riparian coverage of late seral forest, which are mostly on either federal (BLM) or PALCO lands, still support the cold water-adapted torrent salamander (Fig. 5*)*. It is highly unlikely that gene flow presently occurs among the few remaining subpopulations due to the current landscape mosaic of the Mattole watershed. Most tributaries of the Mattole have been continuously and progressively degraded over time to the extent that they are now mostly too shallow, too hot, and with stream habitats too structurally simplified to support the native cold-water adapted species (e.g., Fig. 3*)*.

The most likely explanation for the low abundance of torrent salamander populations on PALCO lands is that stream and riparian habitats have been degraded as a result of timber harvesting with insufficient stream protections. The low abundance of torrent salamanders on PALCO holdings argues strongly for more stringent protections of both Class II and III streams than are currently proposed in the HCP/SYP in order to avoid the likelihood that this species will not survive or recover on this landscape. The importance of LWD in structuring suitable stream habitat for this salamander cannot be overemphasized. It provides structure and habitat complexity in the channel and in riparian areas and traps sediments in streams. Under the current PALCO HCP/SYP, inputs of large woody debris to both Class II and Class III streams would be insufficient. Reid and Hilton (1998) determined that 1.1 site potential tree height no-harvest buffers would be necessary to provide natural recruitment of LWD and thus maintain this vital stream ecosystem process. HW-8

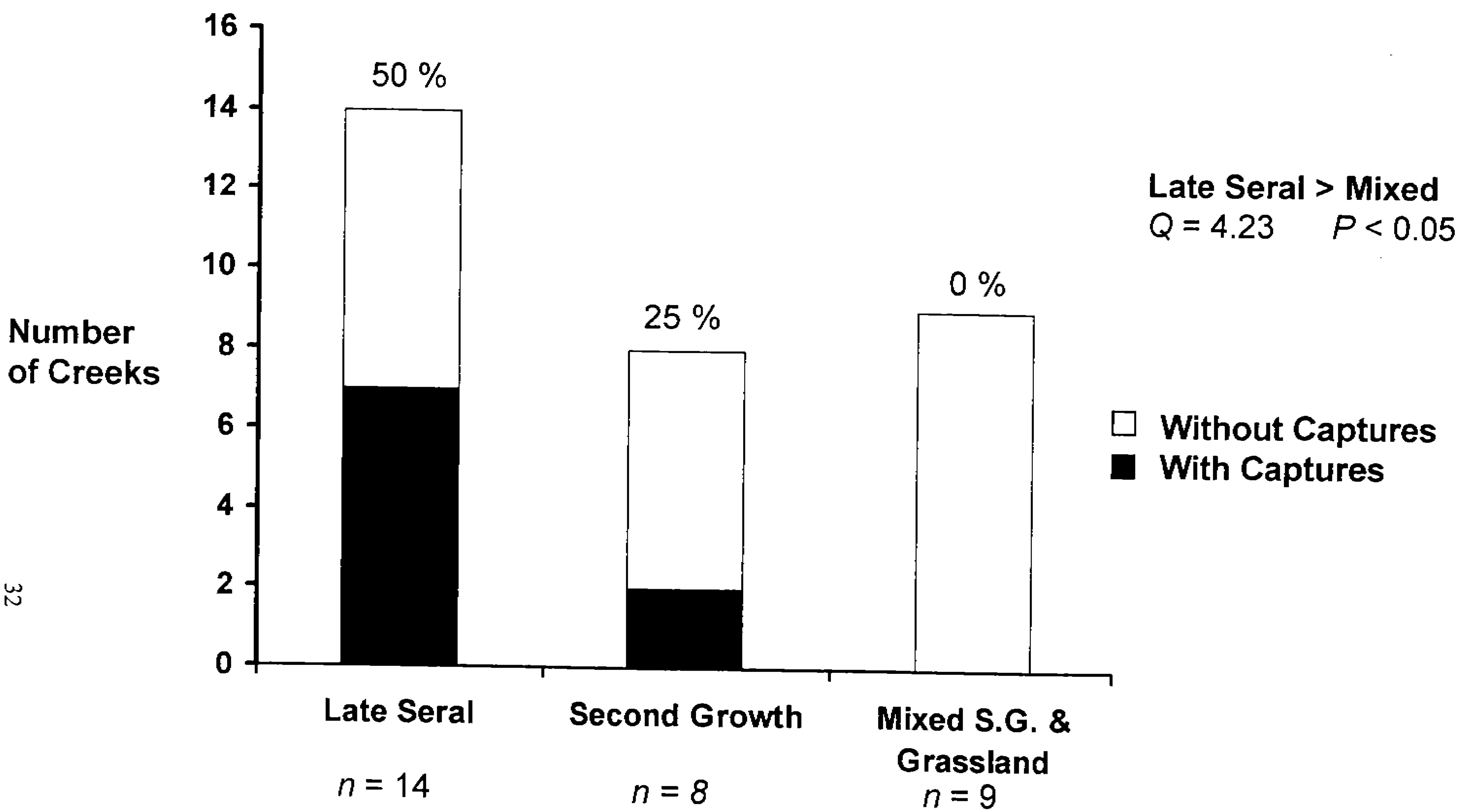

Figure 5. Presence/absence of southern torrent salamanders (*Rhyacotriton variegatus*) at 31 sampling locations in the Mattole River basin during 1994-1996 (Welsh and Hodgson *unpublished data*). Proportion tests are comparisons of sites with salamanders in each of three forest cover types.

Under current forestry rules, and the modifications proposed in the PALCO HCP/SYP, and based on current low abundances, this animal will probably soon be extirpated on the PALCO landscape. Because of the marked declines of this species on adjacent lands, the importance of maintaining viable populations of southern torrent salamanders on PALCO lands is all the more essential. HW-8 CONT.

Monitoring/Adaptive Management

The PALCO HCP/SYP states that an adaptive management plan will be developed for this species. However, the HCP/SYP does not provide adequate information on the details of the plan such that we can evaluate its efficacy for maintaining habitat for, or populations of, the southern torrent salamander. The monitoring and adaptive management sections (Vol. IV, Part D, p. 94-112) focus on fish and fish habitat. While stream amphibians do often have habitat requirements similar to some fish species, these parameters alone are not sufficient to characterize all the aspects of aquatic habitat important to southern torrent salamanders (e.g., low water velocity areas and seep/spring habitats). There is also no discussion of monitoring of the riparian habitats required by the adults of this species. General comments on monitoring and adaptive management are also provided in "Comments on Monitoring and Adaptive Management for the Aquatic Species Conservation Plan"). HW-9

Tailed Frog

Natural History

The tailed frog (*Ascaphus truei*) breeds in headwaters and small streams (e.g., Karraker and Beyersdorf 1997) occurring in highest abundances upstream of waters occupied by anadromous fishes. Larval tailed frogs require streams with cold, clear waters, and clean coarse substrates (Welsh 1993; Welsh and Ollivier, *in press;* Welsh and Lind, *in review.)*. Adults are found in the riparian zone near streams where they forage at night along the stream banks. Adult tailed frogs demonstrate high site fidelity (Daugherty and Sheldon 1982a) and are long-lived (+ 14 years) (Daugherty and Sheldon 1982b). This frog is associated with late seral forest conditions in northern California and recent studies show they are negatively impacted by timber harvesting both in California (Welsh 1990) and in Oregon (Corn and Bury 1989). Based on their dependence on stream and riparian habitats at the upper end of the stream continuum (Fig. 2), tailed frogs are directly affected by land management practices that adversely impact Class II and III channels and the associated riparian forest.

Baseline Condition

To our knowledge, no tailed frog density data are currently available from commercial timberlands. However, we analyzed relative abundance data (captures per unit time) for tailed frogs from 17 streams on PALCO lands (Wroble and Waters 1989). These data provide an appropriate comparison to reference sites with a similar forest type and parent geology in Prairie Creek Redwoods State Park. Wroble and Waters (1989) reported an average of 0.108 (S.D.=0.097) tailed frogs/hour on PALCO lands. Our sampling in ten streams at Prairie Creek Redwoods State Park yielded an average of 2.40 (S.D.=1.58) tailed frogs/hour, a significantly greater abundance than occurred on the PALCO landscape (Mann-Whitney test; $Z = 4.30$, $P < 0.0001$) (Welsh and Ollivier, *unpubl. data*). Given that PALCO lands lie well within the range of this species, and streams in redwood forest in this region typically support high abundances of this frog, the only conclusion we can draw from this comparison is that the streams on PALCO land must be in exceptionally poor condition for tailed frogs. HW-10

The authors of the PALCO HCP/SYP invoked an hypothesis of an unconsolidated parent geology to explain the low abundance of tailed frogs on PALCO lands, but they offered no citations or data to support their argument (Vol. IV, Part E, p. 4). This same hypothesis was thoroughly discredited in the previous section in reference to the torrent salamander and if it is scientifically indefensible for one substrate-dwelling stream amphibian, it is likely not defensible for another on the same landscape, especially without any supporting evidence. The authors of the PALCO HCP/SYP also made reference to stream gradient as being an important predictor of tailed frog presence (Vol. IV, Part E, p. 4), again without supporting data or citations. We examined our tailed frog data from Prairie Creek Redwoods State Park to test this hypothesis. We found no correlation between stream gradient and the presence of tailed frogs ($r = 0.086$, $p = 0.440$; range of gradients = 0-30%, mean = 4.6%, n = 83 Welsh and Ollivier, *unpubl. data*). We believe that the low numbers of tailed frogs on PALCO lands compared with reference sites is strongly indicative of a species in decline due to overall poor stream habitat quality and therefore limited quantities of suitable habitat (e.g., Welsh and Ollivier, *in press*). These low numbers of tailed frogs argue for more stringent protections for both Class II and III channels than are currently provided for by current California Forest Practice Rules or by the proposed PALCO HCP/SYP, in order to maintain this sensitive cold-water adapted amphibian in the stream networks of the PALCO landscape. As currently proposed, the riparian and aquatic prescriptions in the HCP/SYP will not forestall the probable loss of this species on the PALCO landscape. Under both current forestry rules, and the modifications proposed in the PALCO HCP/SYP, and based on current low abundances (Wroble and Waters 1989), this animal will probably soon be extirpated on the PALCO landscape.

HW-10 CONT.

HW-11

Activities With Potential for Impacts

Tailed frogs are probably the most sensitive to ecosystem perturbations of all the stream amphibians in the redwood region. Consequently, the larval stage of this frog has great potential as an indicator of stream "health" (Welsh and Ollivier, *in press*). Larval tailed frogs are logical surrogates for gauging habitat conditions and quality for anadromous fishes, such as coho and chinook salmon, because they are long-lived, show high site fidelity, and require very similar stream microhabitat conditions, such as clean gravels and cold water temperatures (Welsh and Ollivier, *in press*). The most likely explanation for the low abundance of tailed frog populations on PALCO lands is that stream and riparian habitats have been degraded as a result of timber harvesting and related road-building, both with insufficient stream protections. HW-12

Mitigation Measures

Under the current PALCO HCP/SYP, inputs of large woody debris to both Class II and Class III streams would be insufficient(**see** Riparian Vegetation and Large Woody Debris section, p. 13). The important of LWD in structuring suitable stream habitat for this species cannot be overemphasized. It provides structure and habitat complexity in the channel and in riparian areas and traps sediments in streams.

New data from the Mattole watershed indicates that the tailed frog has already declined in that Douglas-fir dominated landscape as a result of anthropogenic changes (both timber harvesting and conversion of forest to grazing lands) (Fig. 6). PALCO has substantial holdings in the Mattole watershed, which would be liquidated under this HCP/SYP. PALCO's late seral habitat in the Mattole includes most of what remains, which is now less than 5% of what existed in 1947 (MRC 1988). The tailed frog is a late-seral associated species (Welsh 1990), and unless HW-13

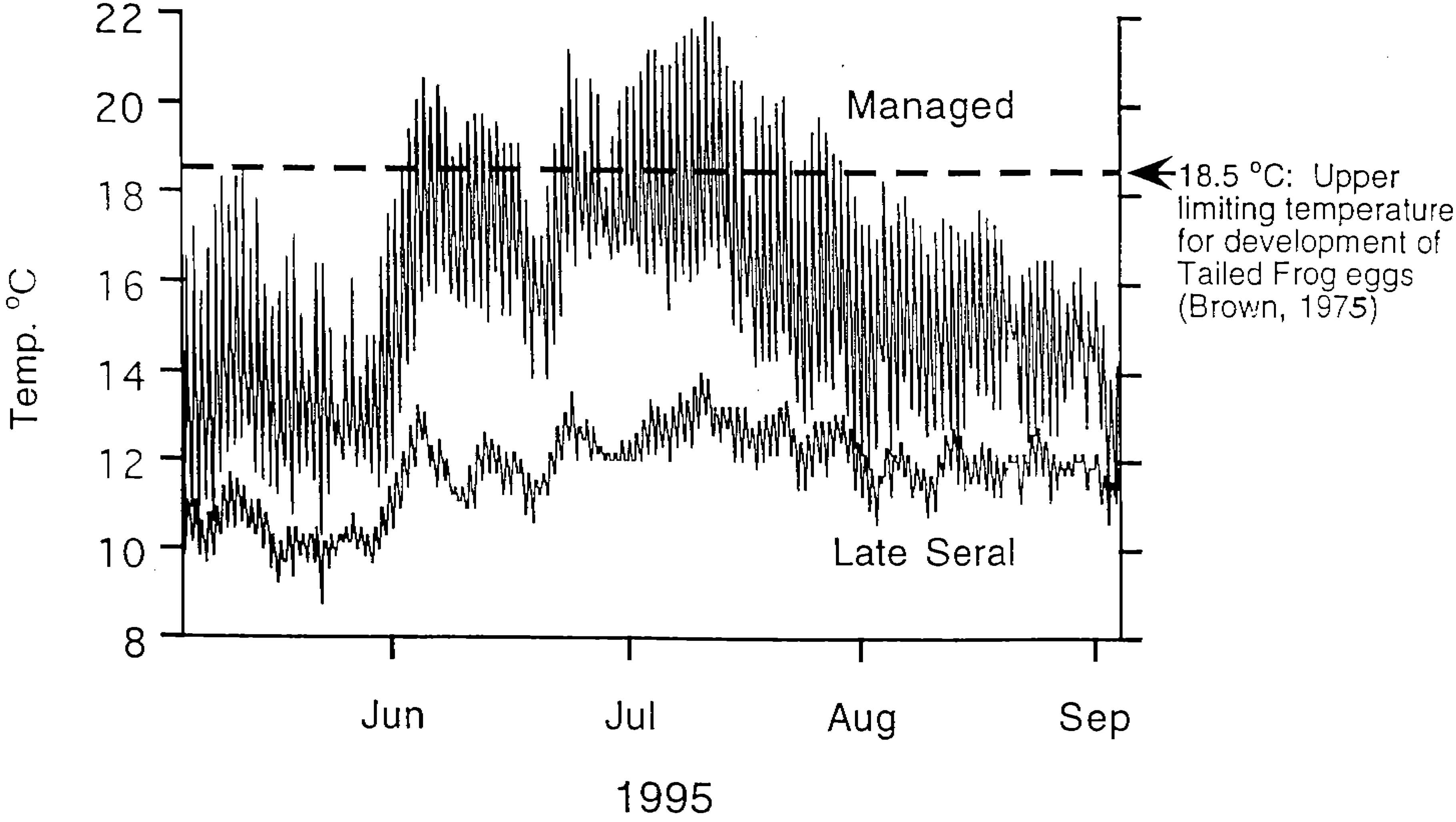

Figure 6. Diel cycle (twenty-four hour) water temperature records for two streams in the Mattole River basin; one managed and one un-managed (late seral) during the summer of 1995 (Welsh and Hodgson, *unpublished data*). The dashed line represents the upper limiting temperature for development of tailed frog (*Ascaphus truei*) eggs based on laboratory data (Brown 1975).

late seral attributes are retained along the stream corridors this species will disappear on this landscape. Adequate protections for riparian and aquatic, late seral associated amphibian species like the tailed frog, require that both stream and riparian forest conditions be suitable, in terms of both essential structural habitat components and requisite microclimatic regimes (i.e. water and air temperature and relative humidity).

We believe the evidence is compelling that timber management in the redwood region has adversely impacted tailed frog populations (see also Corn and Bury 1989, Steventon et al. 1996). We also believe that the proposed management of Class II and III channels in the HCP/SYP is not likely to forestall further declines of the tailed frog on the PALCO landscape. Retaining this species, like the torrent salamander, will require management of the entire channel network by buffering both Class II and III channels with sufficient riparian forest to maintain a properly functioning riparian and aquatic ecosystem with all of its components (Table 1). Especially important is the recruitment of LWD to capture fine sediments and enough streamside forest canopy to maintain sufficient cool, moist riparian microclimate and cold water temperatures (Fig. 7; see also Welsh 1993, Welsh and Lind, *in review*). Ledwith (1996) examined riparian microclimates (air temperature and relative humidity) in the vicinity of PALCO lands, and his results are directly applicable to managing for viable tailed frog populations on PALCO holdings. These frogs are subject to the same physiological stresses as the torrent salamander (sensitive to heat and loss of moisture) and therefore require a stable microclimate in the riparian zone to carry out critical life functions, such as feeding and reproduction (see cites in Welsh 1993). Therefore Ledwith's (1996) conclusion that "...land managers who wish to avoid significantly altering the microclimate of a riparian zone may want

HW-13 CONT.

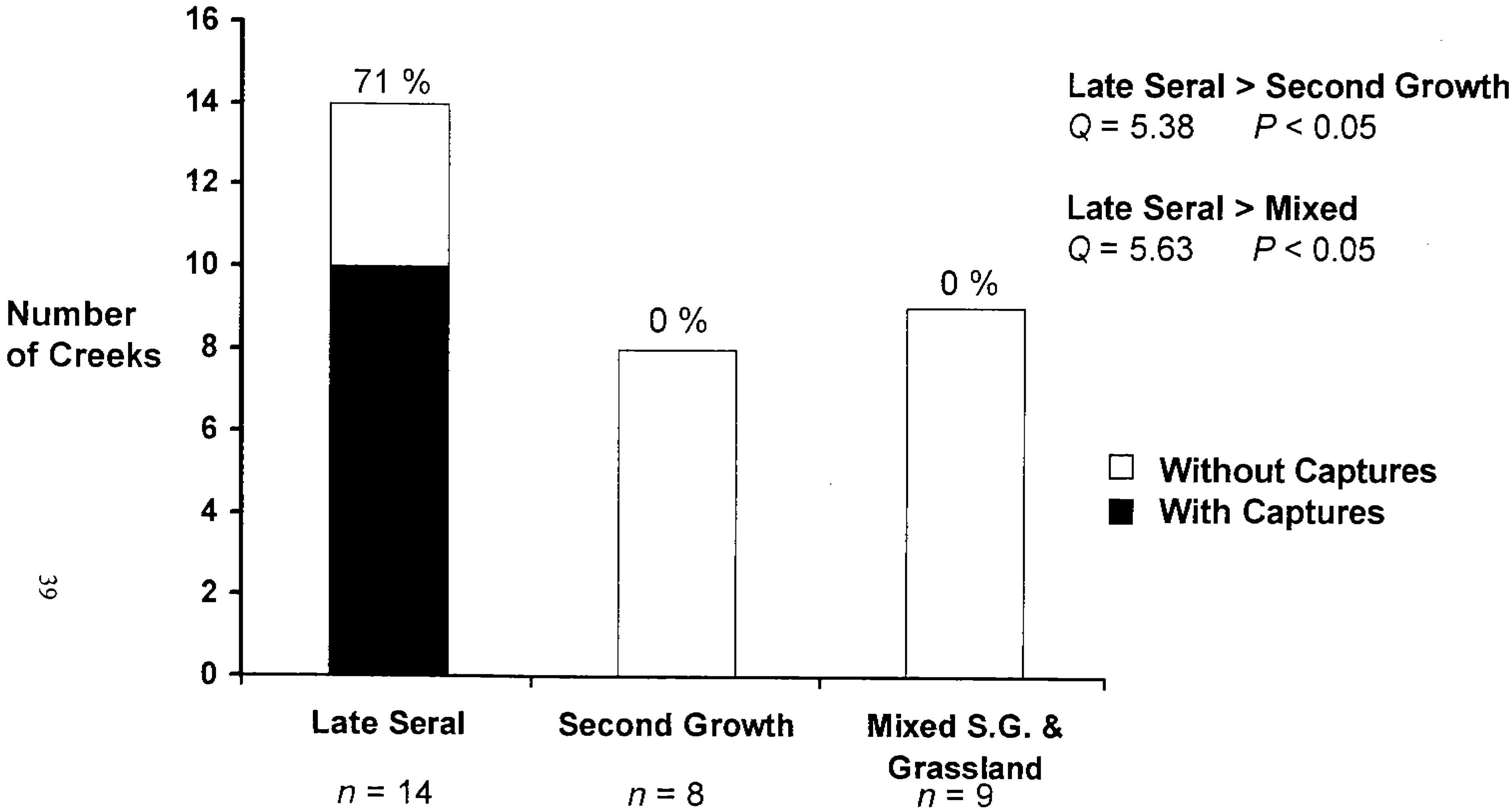

Figure 7. Presence/absence of tailed frog (*Ascaphus truei*) at 31 sampling locations in the Mattole River basin during 1994-1996 (Welsh and Hodgson, *unpublished data*). Proportion tests are comparisons of sites with a tadpoles/frogs in each of three forest cover types.

to leave buffer strips over 30 m (~100 ft) wide..." apply here. With the tailed frog there is good documentation of the importance of the riparian zone in the life history of adults (e.g., Daugherty and Sheldon 1982a & b). What is not known is whether a 30 m buffer is adequate. It may be that considerably more than a 30 m-wide zone is required to sufficiently stabilize the important aspects of microclimate within the streamside riparian zone that influence tailed frog biology (cf. Brosofske et al. 1997). Using a minimum of 30 m of stable microclimate alongside headwater streams during the summer months might accommodate some reasonable percentage of the population of adult frogs at the most stressful time of the year. This minimum would hopefully support viable populations year round until more information could be gathered about their actual riparian habitat needs. However, it is quite conceivable that the complete compliment of riparian processes (Table 1) are important to maintain viable tailed frog populations. As was noted by Ledwidth (1996), for other riparian functions, such as restricting sediment flow and providing the delivery of large woody debris (important for structuring of the habitat for the aquatic larval stage of the tailed frog), the minimum 30 m-width might need to be increased to 60 to 80 meters (~200 - 275 ft) or about one site potential tree height to assure that riparian ecosystems remain sufficiently intact to support tailed frogs on the PALCO landscape. Recent research has determined that 1.1 site potential tree height no-harvest buffers would be necessary to provide natural recruitment of LWD and thus maintain this vital stream ecosystem process (Reid and Hilton 1998). Sufficient information exists on both habitat requirements and microclimatic limitations to design effective stream and riparian protections for cold water-adapted amphibians like the tailed frog (e.g., Welsh 1993, Ledwith 1996, Brosofske et al. 1997, Welsh and Lind, *in review*), but the authors of the PALCO HCP/SYP and the EIS/EIR have failed to incorporate this

HW-13 CONT.

critical information. Consequently, they have failed to meet their mandate of identifying and mitigating all significant adverse impacts on this and all other cold -water adapted amphibian species. The low abundance of tailed frogs on PALCO holdings addressed above argues strongly for more stringent protections of both Class II and III streams than are currently proposed in the HCP/SYP in order to avoid the likelihood that this species will not survive or recover on this landscape. HW-13 CONT.

Potential Impacts of Incidental Taking

The continued isolation and fragmention of headwater habitats and the minimal protections afforded these sensitive areas under current forestry rules and this HCP/SYP (Vol. IV, Part D, p. 30-41), have significant long-term negative genetic consequences (Slatkin 1987) for tailed frog populations on commercial forestlands. This is the case because further isolation and fragmention of headwater habitats exacerbates those constraints on gene flow already present with a highly patchy distribution of isolated subpopulations on the landscape. Metter and Paukin (1969) made the case that fragmentation and isolation have long been a part of the evolutionary history of this frog. Movement studies (Daugherty and Sheldon 1982b) demonstrated that tailed frogs are highly sedentary which could account for some of the high genetic diversity observed among populations. As with the southern torrent salamander, these natural isolating mechanisms have been greatly exaggerated by the current rate of commercial timber harvesting. HW-14

There are few data that can be used to determine just how much fragmentation and isolation this frog species can tolerate across a landscape before going extinct, but evidence from commerical timberlands in the Mattole watershed suggests that this threshold has already been reached or exceeded in this part of the range. Detailed analysis of four years of sampling in the

Mattole River Basin (an area with extensive PALCO holdings) provides evidence for a process of progressive habitat degradation and the associated decline of the tailed frog for this entire major river basin. Aerial photos from 1947 show a watershed that was dominated by late-seral forests (MRC 1988). Available information on fish abundances in the 1940's indicates large, healthy runs of salmon, and based on the extent of contiguous late-seral forest (MRC 1988), it is reasonable to assume also an abundance of associated cold-water adapted amphibians including the tailed frog. We tested the nulll hypothesis that tailed frog distribution was unrelated to vegetation cover. This null hypothsis was rejected, and what we found was that only those few remaining streams with a riparian coverage of late seral forest, which are predominantly on either federal (BLM) or PALCO lands, still support the tailed frog (Fig. 7). It is highly unlikely that gene flow presently occurs among the few remaining subpopulations due to the current landscape mosaic of the Mattole watershed. Most tributaries of the Mattole have been continuously and progressively degraded over time to the extent that they are now mostly too shallow, too hot, and with stream habitats too structurally simplified to support tailed frogs (Fig. 6).

HW-14
CONT.

Nakamoto (1998) reported tailed frog larvae in the Jackson State Forest (Mendocino County) at the North Fork of Caspar Creek, but they were present at such low levels there were too few for statistical analysis. He indicated that tailed frog larvae were entirely absent in the more heavily logged South Fork, which was harvested in the 19th Century and then again in the 1960's (Nakamoto 1998). The scarcity of populations on surrounding lands in the southern portion of the range of this frog, along with increased vulnerability because it is naturally subjected to greater climatic stress at the southern edge of its range (Gates 1993), means that PALCO lands are potentially critical to the survival of the species in this region. Given the marked declines of this species on adjacent lands, it is essential that viable populations of tailed frogs be maintained on PALCO lands. HW-14 CONT.

Monitoring/Adaptive Management

The PALCO HCP/SYP states that an adaptive management plan will be developed for this species. However, the HCP/SYP does not provide adequate information on the details of the plan such that we can evaluate its efficacy at maintaining habitat for and populations of the tailed frog. The monitoring and adaptive management sections (Vol. IV, Part D, p. 94-112) focus on fish and fish habitat. While stream amphibians do have habitat requirements similar to some fish species, these parameters alone are not sufficient to characterize all the aspects of aquatic habitat important to tailed frogs (for example, high water velocity areas, and riffle habitats with unembedded, cobble-dominated, substrates; Welsh 1993) . There is also no discussion of monitoring of the riparian habitats required by the adults of this species. General comments on monitoring and adaptive management are also provided in our review (see Section "Comments on Monitoring and Adaptive Management for the Aquatic Species Conservation Plan"). HW-15

Northern Red-legged Frog

Currently, the genetic relationship is unclear between red-legged frog populations in Humboldt County and the California red-legged frog (*Rana aurora draytonii*) to the south, a Federally-listed species. Here we are assuming that the red-legged frog in Humboldt County is a distinct evolutionary unit, and therefore does not currently fall under the E.S.A. listing.

Natural History

The key habitat requirements for the red-legged frog include breeding habitat (ponds, lakes, bogs, or other small bodies of standing water), and foraging habitat (forest and meadow).

The best available evidence suggests that red-legged frogs exist in meta-populations, a structure where the population is dependent upon numerous breeding sites across the landscape for its long-term viability (e.g., Gulve 1994). This is a natural adaptation by a species to persist following population crashes at individual sites resulting from unpredictable events such as droughts and floods. Given this, all lentic (standing) water bodies on the landscape should be managed as if they have the potential to support frog breeding, whether it is actually observed in any given year or not. It is also important that these ponds be free of bullfrogs, an introduced predator that can eliminate red-legged frogs (Hayes and Jennings 1986).

Activities With Potential for Impacts and Mitigation Measures

Timber harvesting and road-building can change hydro-periods, microclimates, and structural characteristics of the lentic breeding and foraging sites where red-legged frogs occur. Consequently, no-harvest buffer habitat should be maintained around potential breeding sites to protect these values, and to provide both upland foraging and overwintering sites. Semlitsch (1998) calculated that a 164 m (534 ft) buffer around a pond would protect 95% of the population of pond-breeding salamanders at a given site. There are no comparable data yet available for ranid frogs, and no data that compare the relative amounts of overland movements between frogs and salamanders that might shed light on differences between these amphibian taxa. However, adult red-legged frogs are known to disperse into redwood forest, for both foraging and for overwintering, during the non-breeding season. It is reasonable to assume that the calculations made by Semlitsch (1998) for Ambystomid salamanders represent a good "first cut" that would protect a high percentage of a given red-legged frog population using a particular breeding site, and is probably sufficient for long-term maintenance of frog populations.

Unfortunately, both a metapopulation perspective, and adequate buffers for potential breeding sites, are missing from management plan for this species in the HCP/SYP and the EIS/EIR.

The single greatest threat to red-legged frog populations in Humboldt County, discounting habitat distruction from land management activities, may be the use of forest herbicides that can contaminate breeding sites. Amphibians can be particularly sensitive to developmental disruption in the egg and early larval stages (Berrill et al. 1994, 1997). Developmental abnormalities that cause mortality can be triggered by some herbicides at very low concentrations (see section on forest herbicide use below). The use of amphibians as indicators of environmental contamination is a recent development that shows great promise for early warnings of health problems for other vertebrates, including humans. The northern red-legged frog may be one of the best local species for such monitoring. Monitoring red-legged frog populations on the PALCO landscape would allow the company to detect problems before they cause declines in these amphibians, and possibly harm to other life forms in the immediate watershed and beyond. HW-16

Foothill Yellow-legged Frog

Natural History

The foothill yellow-legged frog (*Rana boylii*) occupies larger streams further down the stream continuum than either the tailed frog or torrent salamander, preferring more open areas on rocks and gravel bars. This species breeds in slower-moving microhabitats along these streams and rivers, attaching its eggs to rocky substrates in shallow, slow-flowing water near the stream margins (Zweifel 1955; Fuller and Lind 1992; Lind and Welsh, *unpubl. data*). It is currently listed as a sensitive species by state and federal agencies based on a dramatic decline in abundance in California's Sierra Nevada foothills. Populations of this species appear to be stable in the redwood region, but they are highly susceptible to water diversions and channel alterations which can interfere with the frog's reproductive cycle, resulting in dramatic negative effects on survival and recruitment (Lind et al. 1996).

Activities With Potential for Impacts and Mitigation Measures

There are two obvious short-comings in the HCP/SYP and EIS/EIR regarding the habitat requirements of the foothill yellow-legged frog. The first short-coming consists of a failure to provide for adequate input of large woody debris in the stream network which creates the structural diversity of channel habitats required by this frog for both breeding and foraging habitat (Lind and Welsh, *unpubl. data*). Reid and Hilton (1998) reported a minimum distance of 1.1 site-potential tree heights (250 - 350 ft) along Caspar Creek (Jackson State Forest) as a buffer along stream channels in order to provide for the natural recruitment of LWD into the channel. The second short-coming is the lack of consideration for upland habitat. This species leaves the stream channel during winter high flows and hibernates in the forest where they seek shelter in rodent burrows, under logs, etc. Nussbaum et al. (1983) reports them up to 50 m from the nearest stream. We have captured them up to 100 m from the south fork Eel River (H. Welsh, *pers. obs.*). The 1.1 site potential tree height buffer width delineated by Reid and Hilton (1998) would probably be sufficient to accommodate the terrestrial requirements of a large percentage of the frog population along most channels. Without appropriate stream buffers to provide both upland habitat and LWD, frog populations can be expected to decline across the PALCO ownership. HW-17

Western Pond Turtle

Natural History

The western pond turtle (*Clemmys marmorata*) is the only freshwater turtle that occurs in the redwood region. This turtle is found associated with larger bodies of water, including lakes, ponds, and streams. Their occurrence is patchy; individuals are often associated with relatively deep water with secure basking sites (e.g., logs and rocks surrounded by water), and undercut banks, where they can seek cover to avoid predators like river otters, raccoons, and mink (Reese and Welsh 1998). The pond turtle is a long-lived species and can reach fairly high densities where conditions are favorable. For example, the Mattole River has pond turtles in relatively low numbers overall, but they occur in fair abundance where the habitat is suitable (Welsh et al. *unpubl. data*).

Activities With Potential for Impacts and Mitigation Measures

The level of sediment accumulation in pools associated with timber harvesting, road-building, and gravel mining undoubtedly has a negative effect on pond turtle populations by reducing essential deep water habitats (Reese and Welsh 1998). The current lack of adequate protections of Class II and III channels (under both current forest practices rules and the HCP/SYP) results in fine sediment infusions cascading through the stream continuum (e.g., Lewis 1998), this results in the eventual filling of downstream pools required by turtles for both foraging and escaping predators (Reese and Welsh 1998). While the Class I buffers proposed in the HCP/SYP may be sufficient to protect existing turtle populations along larger channels, juvenile turtles often rear in small channels and backwater areas along large channels (Holland and Bury, *in press*). Water diversions may have negative impacts on this turtle, particularly if HW-18 they reduce the quality and amounts of these shallow, warm, backwater microhabitats required as rearing areas by juvenile turtles (Reese and Welsh 1998). Consequently, the lack of adequate protections in the HCP/SYP for these rearing habitats can result in a loss of recruitment and in a gradual decline in existing turtle populations. HW-18 cont.

This species is long-lived (50+ years; Holland and Bury, *in press*) and has low recruitment (Reese and Welsh, *in press*) so evidence of declines (or mortality) may not be readily apparent. The best evidence of a stable population of these turtles is an age structure with significant proportion of individuals in younger age classes (see Reese and Welsh, *in press*). Any management plan or mitigation for this animal must include a monitoring plan that tracks the age structure of each population in order to determine whether or not mitigations are actually working as proposed. No such monitoring plan appears exists in the HCP/SYP or the EIS/EIR.

Because western pond turtles use upland habitats on a regular and cyclical basis (Reese and Welsh 1997), mitigations must include accommodation for this upland use, which consists of both nesting (females only from May to August in northwestern California) and cross-country travel to satellite bodies of water where turtles both forage and hibernate (adults of both genders). In order to accommodate these land use patterns by turtles, a management plan must take a meta-population view and incorporate ponds, streams, and lakes across the landscape (e.g., Buhlmann 1995). Such a view point is missing from the PALCO HCP/SYP and the EIS/EIR. HW-19

The other omission in this HCP/SYP and EIS/EIR, from the perspective of the western pond turtle, is providing for important natural ecosystem processes (Table 1) that create critical turtle habitat. In particular, the lack of adequate no-harvest buffers along all classes of channels means the recruitment of LWD will not be sufficient to provide this critical habitat element in HW-20 streams (e.g., Reid and Hilton 1998). Turtles require LWD for both basking substrate and escape cover (Reese and Welsh 1998). Given that these considerations are absent from the HCP/SYP and the EIS/EIR, these documents both fail to provide adequate mitigation for the western pond turtle. HW-20 CONT.

Stream Temperature Regimes

PALCO's HCP/SYP states that stream temperatures < 18.4 °C represent suitable aquatic habitat for cold water-adapted species covered by the HCP (Vol 2, Part H, p. 24; see calculation of MWAT [maximum weekly average temperature]), and indicates that this is the water temperature which they used to evaluate the quality of streams on their ownership. We used data from an unnamed tributary of the Mattole River in order to evaluate methods employed by PALCO, and the Forest Science Project (FSP, Humboldt State University), respectively, to calculate MWAT. This tributary had some of the highest water temperatures we recorded in any of the 14 streams we monitored over four years in the Mattole (Welsh and Hodgson, *unpubl. data*). Based on the PALCO method used to calculate MWAT, this stream would fall at the upper limit of suitable habitat that could support cold-water adapted species like coho salmon; the FSP method would not rate it as suitable assuming they used the same < 18.4 °C cut-off value (Fig. 8). Multiple samples (electroshocking) in this tributary in 1994, yielded only steelhead trout (B. Harvey, *pers. comm.*), the most heat-tolerant of the salmonids. Furthermore, 18.4 °C is above thermal stress levels for the southern torrent salamander (Fig. 3) and the tailed frog (Fig. 6), and would undoubtedly cause mortality of individuals of these species as well as prevent their dispersal along this channel. HW-21

The described use of MWAT to determine suitable habitat (i.e. water temperatures) for

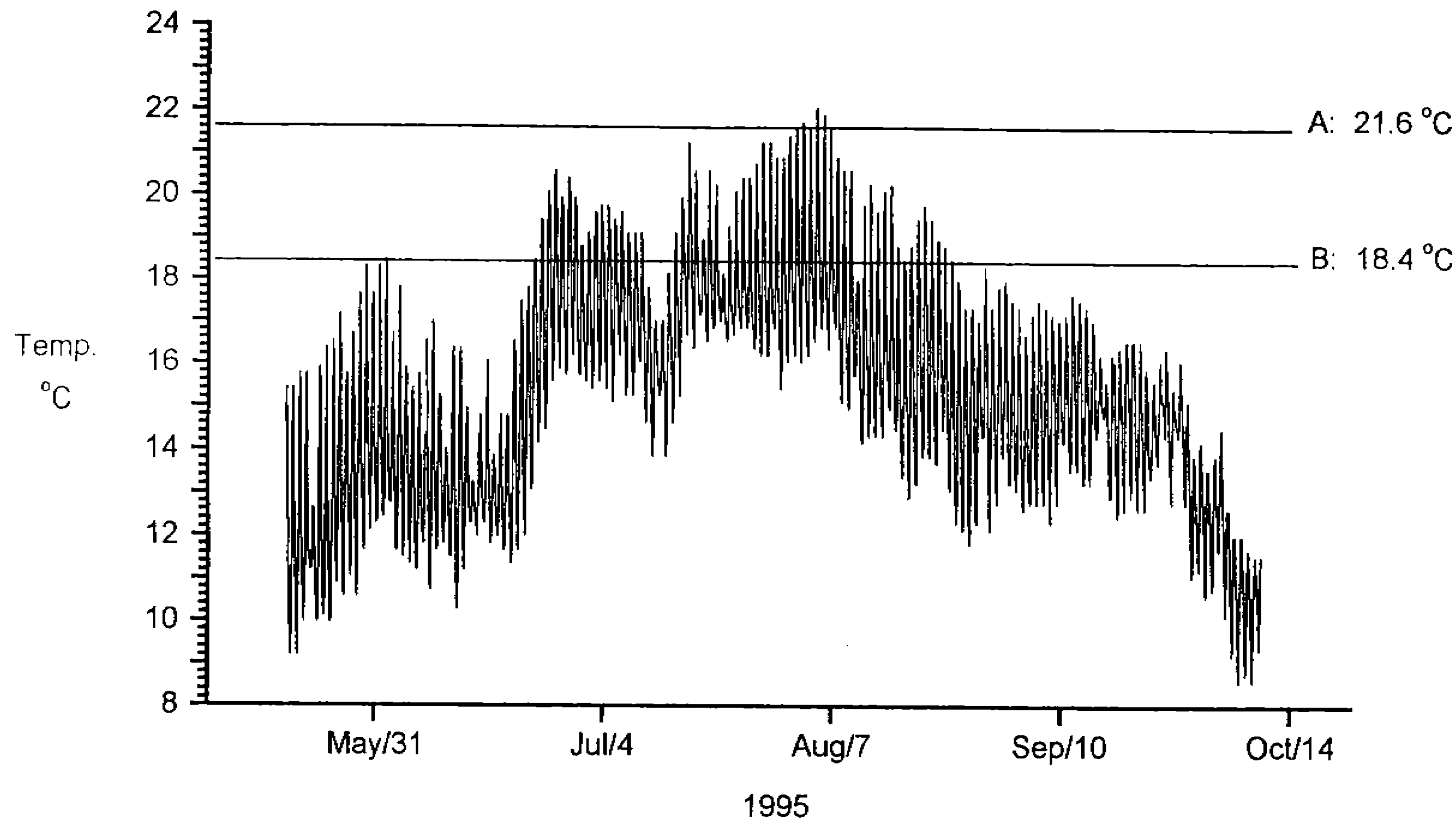

Fig. 8. Comparison of two methods for calculating MWAT (maximum weekly average temperature) using water temperature data from an unnamed tributary of the Mattole watershed. A[1]. Forest Science Project, Stream Temperature Protocol (1998). B[2]. J. Barrett, Pacific Lumber Co., personal communication. See text for details.

A[1]. MWAT is calculated by averaging daily maximum temperatures for each seven-day period and selecting the highest average for the year.
B[2]. MWAT is calculated by averaging daily temperatures for each seven-day period and selecting the highest average for the year.

an aquatic species (Vol 2, Part H, p. 24), is not supported by ecological theory nor is it supported by empirical data (Eaton et al. 1995). There are compelling arguments, based on both the physiological limits of a species and ecological niche thory (Huey 1991, Magnuson et al 1979), that the appropriate way to determine the thermal niche of a species like coho salmon is to use field data measurements taken in association with that species continuously over time (Eaton et al. 1995). To illustrate this approach, we used the PALCO and FSP methods to calculate an MWAT rating for a stream which actually supports coho (based on occurrence records over multiple years) in order to better determine the appropriate MWAT temperature for use in monitoring streams for coho in northwestern California. Our results show that this stream which naturally supports coho yielded an MWAT of 17.3 °C (FSP) or 16.3 °C (PALCO) (Figure 9). Based on this analysis, we believe that PALCO is using an inappropriate interpretation of MWAT for establishing suitable coho habitat. Their standard also is clearly insufficient to evaluate streams relative to their ability to support cold-water adapted amphibians like the southern torrent salamander and the tailed frog. HW-21 CONT.

Late Seral Forest and Wildlife Habitat Requirements

The late seral habitat issue is probably the most contentious of all land management issues in the realm of forest management. There are divergent points of view on both how it should be described and defined, and whether or not it should be protected on private timberlands. It is a simple matter of many users competing for a very limited natural resource. Late seral forests are fundamentally different from managed forests (Hansen et al. 1991). Late seral-associated wildlife species require forest conditions (both structural and microclimatic) created by stands of large old trees, with large decayed logs and standing dead trees (snags).

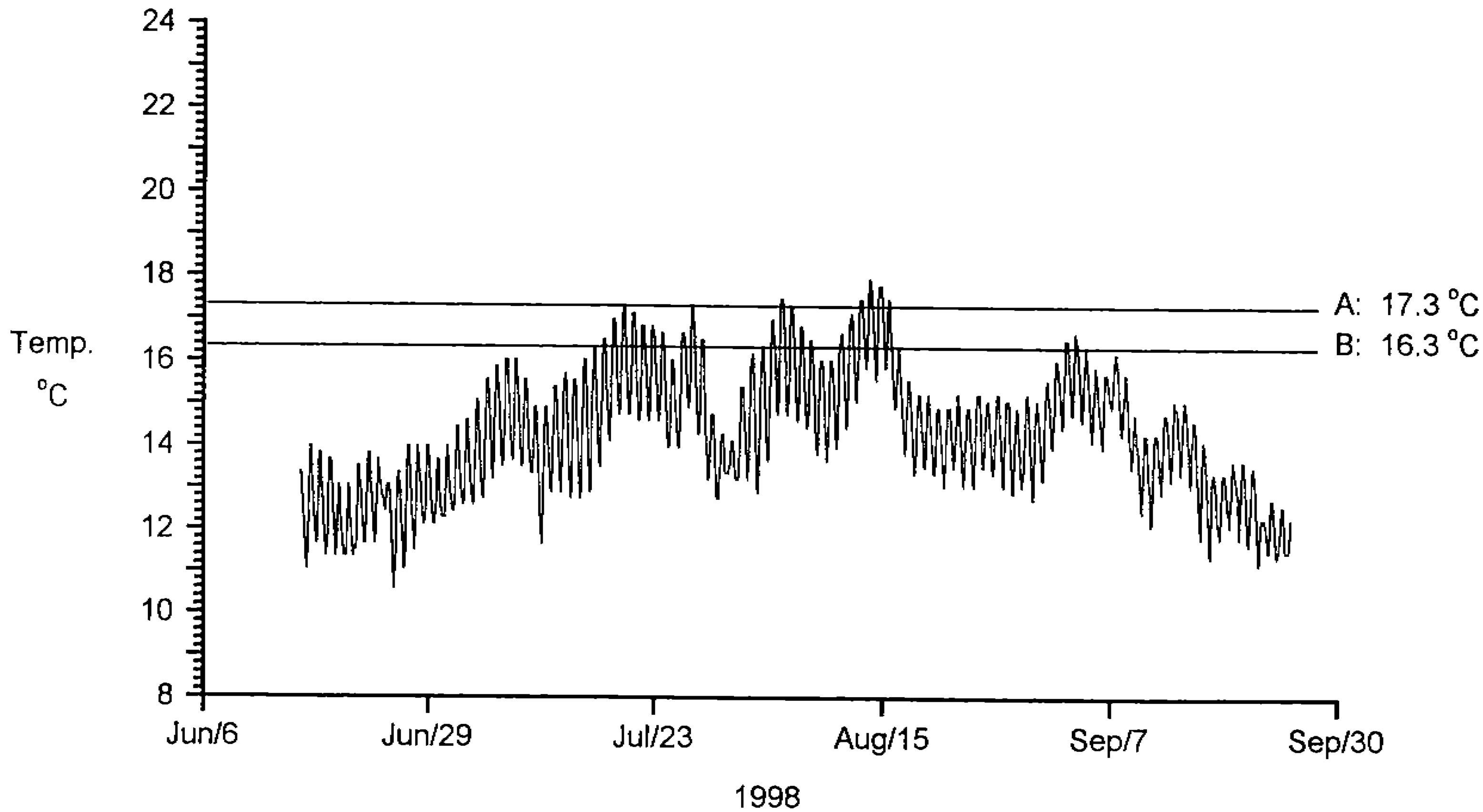

Fig. 9. Comparison of two methods for calculating MWAT (maximum weekly average temperature) using water temperature data from Baker Creek of the Mattole watershed (data supplied by the Mattole Salmon Group). A[1]. Forest Science Project, Stream Temperature Protocol (1998). B[2]. J. Barrett, Pacific Lumber Co., personal communication. See text for details.

A[1]. MWAT is calculated by averaging daily maximum temperatures for each seven-day period and selecting the highest average for the year.
B[2]. MWAT is calculated by averaging daily temperatures for each seven-day period and selecting the highest average for the year.

These stand attributes and their associated microclimates constitute the critical ecological functions of old-growth forest (see Table 1 in Calif. Dept. Fish and Game [1995]; Franklin et al. 1981, Moir 1992,). Yet these same large trees are economically valuable to PALCO only when cut down and milled. Problems of this type are at the heart of every situation where the conservation of species is in conflict with economic gain. For most ecosystems, the greatest difficulty in achieving compromise lies in determining how much of a particular habitat is enough to sustain dependent species, and in what pattern must it occur on the landscape. In most cases the data are lacking to make such estimates on a species by species basis. An often cited minimum value required to sustain an ecologically functional late seral ecosystem found in the scientific literature is 15% late seral forest habitat, juxtaposed within a matrix of four other seral stages, each equally distributed in a given watershed (Harris 1984). This is considered to be the minimum amount required for the survival of late-seral dependent species (California Dept. of Fish and Game 1995), but this recommendation has never been adapted by the California Board of Forestry (BOF). However, even this value is untested as a minimum and considerable scientific opinion would hold that it is grossly insufficient, especially given that it fails to address the critical issue of connectivity (e.g., May 1994, Orians 1993, Kareiva and Wennergren 1995, Tilman et al. 1994). Evidence indicates that changes in species diversity and relative abundance begins to occur with a much lower proportion of the habitat altered by harvesting (see summary in California Dept. of Fish and Game 1995). For example, Reeves et al. (1993) found that the diversity of salmonid species declined when >25% of a watershed was harvested. PALCO's holdings in the Mattole watershed currently contain the majority of the remaining 5% of late seral habitat in that watershed (MRC 1988). Under the HCP/SYP this late seral habitat would be harvested over the next ten years. This high rate of conversion of the last remaining late seral habitat in the Mattole would be devastating to the late-seral dependent species in that basin. The responsible entities (BOF and CDF), and PALCO need to develop an ecologically sound approach to resolving the late seral habitat issue, a solution that will work for this HCP, and that will work to resolve this problem for other companies, and that will assure the sustainability of late seral dependent wildlife species throughout California. HW-22

The BOF and CDF have been aware of this problem for some time (Wildlife/Science Committe 1994), but have failed to adequately address it despite issuing guidelines for the retention of late seral habitat (California Forest Practice Rules 919.16, 939.16.959.16). The biggest problem is that the definition of late seral habitat is not sufficiently clear in the rule, and thus, on any particular piece of ground, the determination is left up to the foresters and CDF inspectors. This appears to be a conflict of interest on the part of the foresters, and the CDF inspectors, as part of the "forestry culture" (Wildlife/Science Committe 1994), are under pressure to follow the forester's interpretation and do in most instances. The State's definition of late-seral needs to be consistent with the scientific literature (FEMAT 1993, SAT 1993, Moir 1992, Franklin et al. 1986, Franklin et al. 1981), and the mechanics of how this definition is applied on the landscape needs to be clearly spelled out in the forest practice rules. HW-23

Presently, if any particular species requires more protection than is currently granted by the California Forest Practice Rules, the California Endangered Species Act, or the Federal Endangered Species Act, the burden of proof is on that government agency charged with protecting that species. This is a formula for continued declines in late seral-dependent species across the landscape because of both internal conflicts and reduced budgets and workforces in these agencies. The result is that populations are extirpated before an understanding of how much late-seral forest a species requires is ever acheived. Changing the burden of proof from the government agencies to both the private land owner and the interested public, with some incentives to preserve the resource might help society achieve some common ground on this contentious issue. There is no reasonable solution offered in this HCP. PALCO's current definition of 'late-seral habitat,' is trees with a 24 inch DBH (diameter-at-breast-height) (HCP Vol. I, p 29). At this tree size, stands have not developed other attributes (large downed logs, multi-storied canopy with an open understory, etc.) required to meet the definition of late-seral forest found in the scientific literature (California Department of Fish and Game 1995). Consequently, species on PALCO lands with an ecological dependence (Ruggiero et al. 1988) on late-seral habitats, other than those highly mobile species like the marbled murrelet (which is specifically addressed by this HCP/SYP), will not be adequately protected by the plan, and can be expected to disappear across this landscape (e.g., tailed frog, torrent salmander [Welsh 1990], Humboldt marten, fisher, etc.).

itW-24

Herbicides and Forest Ecosystem Health

Recent research on chemical disruptions of the endocrine systems of animals indicates that many common industrial chemicals can have profound and long-lasting adverse effects on many vertebrates species, including humans (Colborn and Clement 1992, Colborn et al. 1993, Colborn et al. 1996, EPA 1997). At this point in time, the Environmental Protection Agency (EPA) has no formal tests or screening processes established for detecting these commercially available hormone-mimicking and hormone-blocking chemicals (EPA 1997). Adverse effects can occur with even miniscule doses (parts per trillion) of some of these chemicals (Colborn and

Clement 1992, Colborn et al. 1993, Colborn et al. 1996, EPA 1997). This hormone-mimicking mechanism has been proposed as a possible explanation for the current, pervasive breast cancer epidemic in western society (Davis et al. 1993). Many chemical herbicides used on PALCO forests have been documented to mimic the female hormone estrogen (e.g., 2,4-D, 2,4,5-T, atrazine; Colborn et al. 1993). These herbicides have also been linked to deformities or mortalities in birds, mammals, amphibians, reptiles, and fish (Hall and Henry 1992, Colborn et al. 1993, Berrill et al. 1994, Berrill et al. 1997). In the absence of studies of any particular chemical which demonstrate that it is not harmful to the species of concern in this HCP/SYP, and in the interest of ecosystem health, the safest approach currently available would be to avoid the use of all of these chemicals. AW-25

Monitoring and Adaptive Management for the Aquatic Species Conservation Plan

The importance of a scientifically-based and locally relevant monitoring plan cannot be overstated. Monitoring is a critical link in adaptive management because it provides the new information that is incorporated into subsequent decisions and management actions (Mulder et al. 1997). Management actions are often made with some degree of uncertainty. Monitoring and adaptive management allow for adjustment of management approaches over time as this level of uncertainty changes (Walters 1986). A successful monitoring program must include the following key steps: (1) specify goals and objectives, (2) characterize stressors and disturbances, (3) develop conceptual models - outlines pathways from stressors to the ecological effects on one or more resources, (4) select indicators - detects stressors acting on resources, (5) determine detection limits for indicators - to guide sampling design, establish "trigger points" for management intervention, and (6) establish clear connections to the management decision process (Mulder et al. 1997). The establishment of "trigger points" for management action are the mainstay of the adaptive management process. Clear articulation of the values of these points will help avoid losses of species and habitat degradation that otherwise might occur through benign neglect (e.g., Bella 1997).

As with many other sections of the HCP/SYP, the intention of the Monitoring and Adaptive Management Plan sections (Vol. IV, Part D, Section 1, p. 94-112) appear to be on target, but the critical details of implementation are incomplete or missing. In addition, there are some significant shortfalls in the approaches described. Also, there are numerous references cited in the text in this section which do not appear in the associated "References" section (e.g., Grost and Hubert 1991, Harrelson et. al. 1994, Flosi and Reynolds 1996). There are also recent and important documents on monitoring which were clearly not consulted for this section (e.g. Mulder et al. 1997, Lear and Chapman 1994). AW-26

The PALCO HCP/SYP monitoring plan has a clear bias toward fish, which we believe gives one an incomplete perspective on critical riparian and aquatic ecosystem functioning (see Roper et al. 1997). All the sample monitoring questions in the HCP are fish or fish-habitat related, with the commendable exception that habitat variables recorded for fish species in Class I stream reaches, should also be recorded for other species in Class II stream reaches. Species and population level monitoring is only directed at fish species, with habitat monitoring touted as the monitoring approach for amphibians and reptiles. Habitat monitoring requires either data-based, or verified habitat-association, models for the species of interest. These currently do not exist for many of the species of concern. Habitat modeling can be a goal (see Mulder et al.

1997), but in the short-term, some direct monitoring of species would be necessary to determine the effectiveness of the "Aquatic Species Conservation Plan" and to refine habitat models for selected species on PALCO holdings. In addition, a major weakness of habitat monitoring is that population declines due to stressors not related to habitat or to the component of habitat being measured would be missed (Mulder et al. 1997). HW-26 CONT

Another significant shortfall is the lack of a monitoring plan for stream-side (riparian) habitats. These habitats provide cover and foraging substrates for many adult amphibians and reptiles. While canopy closure (affecting water temperature) and tree abundance are identified in the "Key Goals for Properly Functioning Condition Identified by the Interagency Matrix" (Vol. IV, Part D, Section 1, Table 7), there is no description of how these variables will be measured or monitored. The in-channel focus of this monitoring plan misses the inherent function of the riparian vegetation (Fig. 1) as well as its link to stream channel processes. HW-27

A major concern is the lack of identification of clear "trigger points" for management intervention. In the sections on Habitat Condition Goals (Vol. IV, Part D, Section 1, p. 96-99) and Monitoring (Vol. IV, Part D, Section 1, p. 99-111) it is stated that the goal for effective land management is that monitored variables will trend toward the stated "Habitat Condition Goals" with a trigger point of "stream conditions do not trend toward key properly functioning goals identified by the agencies (Vol. IV, Part D, Section 1, Table 7)." Trigger points are also generically established as "trending away from these goals". This language is vague and confusing. There is no way to tell what the standard really is supposed to be. For example, for water temperature, a significant increase in temperature is required before there is management intervention (i.e. agency consultation). Here, there also is not enough information on the HW-28 methods for determining a significant increase, to allow evaluation of this trigger point. Similar problems exist for other stream and channel variables. Of potentially greater concern is that this approach does not address the streams that are currently in degraded conditions, with already lethal water temperatures for aquatic biota on PALCO's holdings (see Vol. II, Part H, especially p. 21 and 25). HW-28 CONT.

Comparison of Alternatives for Protection of List A Herpetofaunal Species

In the following section we are defining "riparian buffer" as a zone along or around a wetland or stream where no timber harvest is permitted on either side of the stream channel or standing body of water. Table 3 provides a summary of the EIS alternatives we used to evaluate each one relative to the species below.

Alternative 1: No Action/No Project

The analysis of Alternative 1 in the EIR/EIS was addressed differently by CDF and NMFS due to differences in the ways in which CEQA and NEPA assess environmental impacts to aquatic resources. CEQA requires an analysis of near-term impacts and NEPA requires a long-term projection. Consequently, the CDF approach considers Alternative 1 equivalent to the California Forest Practice Rules. Since the coho salmon was listed as federally threatened, NMFS has been evaluating measures that would prevent take of this species. These measures most closely resemble those developed by the Forest Ecosystem Management Assessment Team (FEMAT), but they have not yet been incorporated into the California Forest Practice Rules. In the NEPA analysis of Alternative 1, NMFS was required to considered these proposed aquatic system measures, as they have potential for long-term impacts. The California Forest Practice

Table 3. A comparison of aquatic resource protection by Alternative in the PALCO Habitat Conservation Plan Draft EIR/EIS.

Alt.	No-Harvest Reserves	Class I Stream Measures Outside of Reserves	Class II Stream Measures Outside of Reserves	Class III Stream Measures Outside of Reserves
1	None	Salvage permitted within channel Slopes <30%: 75 ft. zone, 50% canopy retained Slopes 30-50%: 100 ft. zone, 50% canopy retained Slopes >50%: 150 ft. zone*; 50% canopy retained *Subtract 50 ft. for cable yarding	Salvage permitted within channel Slopes <30%: 50 ft. zone, 50% canopy retained Slopes 30-50%: 75 ft. zone, 50% canopy retained Slopes >50%: 100 ft. zone*; 50% canopy retained *Subtract 25 ft. for cable yarding	Salvage permitted within channel 50% understory canopy retained
2	16,788 ac.	No harvest or salvage within channel 30 ft. restricted harvest zone[1] 30-100 ft. selection harvest zone, cable only 300 sq. ft. post-harvest basal area 100-170 ft. selection harvest zone 240 sq. ft. post-harvest basal area 10 trees/ac.>40 in DBH in first two zones trees permanently marked (interim[2]: trees not permanently marked)	No harvest or salvage within channel 30 ft. restricted harvest zone[1] (interim[2]: 10 ft.) 30-100 ft. selection harvest zone, cable only 240 sq. ft. post-harvest basal area (interim[2]: 10-100 ft.)	Harvest and salvage permitted within channel Slopes<30%: 25 ft. ELZ[3] Slopes 30-50%: 50 ft. ELZ Slopes >50%: 100 ft. ELZ All down wood retained
3	18,401 ac.	100 ft. restricted harvest zone[1] 240 ft. selection harvest zone late seral prescription	75 ft. restricted harvest zone[1] 95 ft. selection harvest zone late seral prescription	25 ft. restricted harvest zone[1] 75 ft. selection harvest zone late seral prescription
4	63,673 ac.	No harvest or salvage within channel 30 ft. restricted harvest zone[1] 30-100 ft. selection harvest zone, cable only 300 sq. ft. post-harvest basal area 100-170 ft. selection harvest zone 240 sq. ft. post-harvest basal area 10 trees/ac.>40 in DBH in first two zones trees permanently marked (interim[2]: trees not permanently marked)	No harvest or salvage within channel 30 ft. restricted harvest zone[1] (interim[2]: 10 ft.) 30-100 ft. selection harvest zone, cable only 240 sq. ft. post-harvest basal area (interim[2]: 10-100 ft.)	Harvest and salvage permitted within channel Slopes<30%: 25 ft. ELZ Slopes 30-50%: 50 ft. ELZ Slopes >50%: 100 ft. ELZ All down wood retained

[1] Timber harvesting can occur within these zones only to enhance and facilitate riparian functions and must be based on completed watershed analysis and a riparian management plan agreed upon by the permitting agencies.

[2] Interim measures will be applied to timber harvest plans submitted or pending after February 27, 1998, before Incidental Take Permit issuance and for three years after the issuance of an Incidental Take Permit.

[3] ELZ = Equipment Limitation Zone

Rules represent a worst-case biological scenario for aquatic resources, when compared with the FEMAT measures. Thus, in order to take a biologically conservative approach, Alternative 1 was considered the equivalent of the California Forest Practice Rules for our analysis.

Southern Torrent Salamander (*Rhyacotriton variegatus*)

and Tailed Frog (*Ascaphus truei*)

The primary effects of Alternative 1 on torrent salamanders and tailed frogs are associated with microclimate changes in the streams and riparian areas resulting from a 50% reduction in total canopy in Class I and Class II streams. Permitted salvage of woody debris within Class I, II, and III stream channels reduces the quantity and complexity of aquatic habitat for both species, and habitat and food for their invertebrate prey. With the permitted salvage within Class III channels and retention of only 50% understory, and no overstory, loss of canopy will result in microclimate changes. The lack of protections along Class III channels will result in sedimentation that will extend to Class I and II streams and impact both species. HW-29

Northern Red-legged Frog (*Rana aurora aurora*)

Red-legged frogs breed in lakes, ponds, bogs, and small bodies of standing water and are also found in riparian areas and moist forests. Wetland protection measures under all alternatives are equivalent to Class II watercourse protection measures. Under Alternative 1, the primary impacts to this species result from microclimate changes due to a 50% reduction in total canopy around breeding sites and disturbance-related sedimentation. HW-30

Foothill Yellow-legged Frog (*Rana boylii*)

Yellow-legged frogs typically breed in Class I streams, forage in and around Class I and Class II streams, and frequently overwinter in riparian areas. Under Alternative 1, yellow-legged HW-31 frogs will be most impacted by sedimentation due to inadequate restricted harvest zone widths (riparian buffers) and disturbance of riparian foraging and overwintering areas due to timber harvesting within these areas. HW-31 CONT.

Northwestern Pond Turtle (*Clemmys marmorata marmorata*)

The northwestern pond turtle is associated with Class I streams, ponds, and lakes, and utilizes terrestrial overwintering and breeding sites. The primary impacts of Alternative 1 to this species result from sedimentation due to inadequate restrictions within the riparian buffers and disturbance in riparian areas. Excessive sediment fills underwater cover habitat making the species vulnerable to predators. A lack of woody debris recruitment due to narrow riparian buffers and permitted salvage of wood from the channel and riparian areas will result in declining quantities of basking sites over time. Northwestern pond turtles nest and overwinter in upland areas; Alternative 1 offers no protection for these areas.

In summary, the aquatic resource protection measures contained in Alternative 1 are inadequate to maintain viable populations of southern torrent salamanders, tailed frogs, northern red-legged frogs, foothill yellow-legged frogs, and northwestern pond turtles in the project area. HW-32

Alternative 2: Proposed Action

Alternative 2 proposes 16,788 acres of no-harvest reserves (the Headwaters buy-out and Marbled Murrelet Conservation Areas) which would provide protection of any breeding, foraging, and cover habitat for these five species within those reserves. HW-33

Southern Torrent Salamander (*Rhyacotriton variegatus*)

and Tailed Frog (*Ascaphus truei*)

The prohibition of harvesting and salvage within Class I and II stream channels will help HW-34 maintain the complexity of instream habitat for torrent salamanders, tailed frogs, and their invertebrate prey. The retention of 10 trees/acre > 40 inches DBH on Class I streams will help provide woody debris recruitment to the channel and riparian area, thereby maintaining habitat complexity. However, the riparian buffer zones are not sufficient to maintain a suitable microclimate for tailed frogs and torrent salamanders (see species reviews for details). In Class III channels, permitted harvest and salvage will result in sedimentation impacts to downstream Class II and I channels and increased water temperature.

HW-34 CONT.

Northern Red-legged Frog (*Rana aurora aurora*)

Under Alternative 2, breeding sites will be given protection equivalent to the California Forest Practice Rules for Class II watercourses. As stated under Alternative 1, the primary impacts of timber harvesting operations will result from microclimatic changes around breeding sites and disturbance-related sedimentation.

HW-35

Foothill Yellow-legged Frog (*Rana boylii*)

Alternative 2 poses the same impacts to yellow-legged frogs as Alternative 1. Inadequate riparian buffers will result in sedimentation of breeding and cover habitats, and disturbance due to timber harvesting within riparian areas will impact foraging and overwintering areas.

HW-36

Northwestern Pond Turtle (*Clemmys marmorata marmorata*)

The prohibition of harvesting and salvage within Class I and II stream channels and retention of 10 trees/acre > 40 inches DBH will help to recruit woody debris for cover and basking sites. However, as in Alternative 1, the narrow riparian buffers will not reduce impacts due to sedimentation. In this Alternative, there are no protection measures for hillslope nesting and overwintering sites.

HW-37

Alternative 2 provides better protection for the five herpetofaunal species than Alternative 1. However, we conclude that the aquatic resource protection measures contained in Alternative 2 are inadequate to maintain viable populations of southern torrent salamanders, tailed frogs, northern red-legged frogs, foothill yellow-legged frogs, and northwestern pond turtles in the project area. HW-37 CONT.

Alternative 3: Property-wide Selective Harvest

Alternative 3 proposes 18,401 acres of no-harvest reserves (the Headwaters buy-out and Marbled Murrelet Conservation Areas) which would provide protection of any breeding, foraging, and cover habitat for the five species within those reserves.

Southern Torrent Salamander (*Rhyacotriton variegatus*)

and Tailed Frog (*Ascaphus truei*)

This alternative significantly improves upon previous alternatives in terms of microclimate protection. The increased restricted harvest zones (100 ft. and 75 ft., respectively) on Class I and II streams may be enough to protect torrent salamanders and tailed frogs during the warmest months of the year. Buffers on Class III channels will protect microclimates further downstream. Larger riparian buffers will also provide for woody debris recruitment and reduce sedimentation in the stream channels. HW-38

Northern Red-legged Frog (*Rana aurora aurora*)

Under this alternative, breeding sites will still receive the buffers required on Class II streams under the California Forest Practice Rules. However, riparian areas associated with streams, where these frogs often forage, will be less impacted by timber harvesting. HW-39

Foothill Yellow-legged Frog (*Rana boylii*)

This alternative will result in reduced sediment delivery to streams and increased woody debris recruitment to stream and riparian areas, due to wider riparian buffers. These buffers should improve breeding and cover habitats for this species. HW-40

Northwestern Pond Turtle (*Clemmys marmorata marmorata*)

Alternative 3 will result in reduced sediment delivery to streams and increased woody debris recruitment to the stream and riparian areas, due to wider riparian buffers. These buffers should improve basking and cover habitats for this species. As this alternative proposes only selection harvesting on the whole ownership, the impacts to nesting and overwintering habitats should be reduced. HW-41

Alternative 3 provides better protection for the five herpetofaunal species than any of the other alternatives, but it still contains some shortcomings. Specifically, Class II and III streams do not receive adequate riparian protection. Thus this alternative will not likely maintain viable populations of southern torrent salamanders, tailed frogs, northern red-legged frogs, foothill yellow-legged frogs, and northwestern pond turtles in the project area.

Alternative 4: No-harvest Reserve

Alternative 4 proposes 63,673 acres in a no-harvest reserve (the Headwaters buy-out and Marbled Murrelet Conservation Areas) which would provide good protection of any breeding, foraging, and cover habitat for the five species within the reserve. HW-42

Southern Torrent Salamander (*Rhyacotriton variegatus*)

and Tailed Frog (*Ascaphus truei*)

As the aquatic resource protection measures outside of the no-harvest reserve for this alternative are the same as for Alternative 2, please see comments above. HW-43

Northern Red-legged Frog (*Rana aurora aurora*)

As the aquatic resource protection measures outside of the no-harvest reserve for this alternative are the same as for Alternative 2, please see comments above. HW-44

Foothill Yellow-legged Frog (*Rana boylii*)

As the aquatic resource protection measures outside of the no-harvest reserve for this alternative are the same as for Alternative 2, please see comments above. HW-45

Northwestern Pond Turtle (*Clemmys marmorata marmorata*)

As the aquatic resource protection measures outside of the no-harvest reserve for this alternative are the same as for Alternative 2, please see comments above. HW-46

Conclusions

Given the current and extensive scientific literature on the 'whole system' or 'ecosystem approach' for managing riparian and aquatic resources that was readily available to (and much of it even cited by) the authors of the PALCO HCP/SYP, the degree to which they failed to incorporate the basic principles of this approach is both puzzling and disappointing.

The greatest single flaw in the approach taken in this HCP is its reliance on the fish-biased and ecologically flawed stream classification system of CDF. As a consequence, this HCP/SYP lacks credibility in both resource assessment and management prescriptions (Reid 1998:486). The result is that the authors of this HCP/SYP have failed to identify all significant adverse impacts on numerous riparian and aquatic life forms, and thus, have failed to minimize and mitigate the impacts of taking that will occur. The result is that the extent of continuing take, especially of cold-water adapted amphibians and fish (e.g,. coho salmon), will reduce the HW-47 likelihood of the survival and recovery of these species on the PALCO landscape. The EIS/EIR, in failing to identify this major conceptual short-coming in the PALCO HCP/SYP, has failed to meet its mandate to adequately describe the project, the setting, and to objectively analyze the direct and indirect cumulative environmental impacts of the HCP/SYP. This major oversight HW-48

also means that even under the no action alternative (alternative 1), because so much habitat alteration and degradation has occurred, and continues to occur on the PALCO landscape, the EIS/EIR has failed to analyze and propose a reasonable range of alternatives that will mitigate these significant impacts, especially increased water temperature and the loss of LWD. HW-49

In particular, as currently proposed, the 30 foot 'restricted harvest zone' on Class I streams and the 10 foot (interim) to 30 foot 'restricted harvest' zones alongside Class II streams, (Vol. I, Part D, p 30-41) may be mostly 'edge' habitat, and lack sufficient 'interior core' areas where terrestrial microclimates would be adequately ameliorated and stabilized. Creating interior or core areas of riparian forest where conditions would be suitable for cold-water adapted amphibians would require expanding the currently proposed 'restricted harvest' zone into a wider no cut buffer configuration (> 30 m). This is necessary in order to provide the microclimate required by the adult life stages of several amphibians addressed by this HCP/SYP (e.g., tailed frog, southern torrent salamander). Furthermore, without retention of the larger size classes of conifers (especially California Wildlife Habitat Relationships [Mayer and Laudenslayer 1988] Class 5) within such a system of enlarged channel buffer zones, the larger trees will be continuously selected for harvest and unavailable to contribute LWD necessary for creating the structurally diverse aquatic habitats needed by the larval life stages of these species within the streams. HW-50

Furthermore, the failure of the PALCO HCP/SYP to address streams as ecological continuua and provide adequate no harvest riparian buffer protections for headwater tributaries (both class II and III) means that important food web relationships have been, and will continue to be, compromised on PALCO lands. Headwater tributaries are the primary source of the very fine sediments, usually released during storm events, which plug substrate interstices and thus destroy critical aquatic habitats. Current best scientific research indicates that riparian protections need to extend from Class I channels to the upper portions of drainage networks (Class II and III channels) and should be even more extensive along these upper channels than they are along Class I channels. If left at the levels of protection specified in in the PALCO HCP/SYP (and CDF regulations), these Class III channels will continue to contribute to the degradation of aquatic ecosystems on PALCO lands. HW-51

Lastly, the HCP/SYP fails to adequately address the loss of late seral habitat across the landscape and the detrimental impacts this will have on late seral-associated species on this 200,000 acre landholding. The EIS/EIR also fails to adequately consider the impacts of the fragmentation and loss of these late seral habitats across many watersheds of the PALCO holdings. HW-52

Considering our analysis of the amphibians and reptile covered by the PALCO HCP/SYP, and the cursory discussion and analysis of the proposals of the HCP/SYP for these same species by the EIS/EIR (Chapter 3.10, p. 117-123), we believe that the lack of any recommended changes to the proposed mitigations of the HCP/SYP indicates a failure to base the conclusions of the analysis on the best available science.

LITERATURE CITED

Andrus. E. W. 1988. Woody debris and its contribution to pool formation in a coastal stream 50 years after logging. Canadian Journal of Fisheries and Aquatic Sciences 45:2080-2086.

Bella, D. A. 1997. Organizational systems and the burden of proof. Pp. 617-638 *in*: Stouder, D. J., P. A. Bisson, and R. J. Naiman, eds. Pacific salmon and their ecosystems: status and future options. Chapman and Hall, New York.

Bencala, K. E. 1984. Interactions of solutes and streambed sediments. 2. A dynamic analysis of coupled hydrologic and chemical process that determine solute transport. Water Resources Research 20:1804-1814.

Berrill, M., S. Bertram, L. McGillivary, M. Kolohon, and B. Pauli. 1994. Effects of low concentrations of forest-use pesticides on frog embryos and tadpoles. Environmental Toxicology and Chemistry 13(4):657-664.

Berrill, M., S. Bertram, and B. Pauli. 1997. Effects of pesticides on amphibian embryos and larvae. Pp. 233-245, in: D. M. Green, editor. Amphibians in decline: Canadian studies of a global problem. Herpetological Conservation No. 1.

Beschta, R. L., R. E. Bilby, G. W. Brown, L. B. Holtby, and T. D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. *In*: E. O. Salo and T. W. Cundy, eds., Streamside management: forestry and fishery interactions. Institute of Forest Resources, University of Washington. Contribution no. 57. Seattle, Wash.

Boulton, A. J., and P. S. Lake. 1991. Benthic organic matter and detritivorous macroinvertebrates in two intermittent streams in south-eastern Australia. Hydrobiologia 241: 107-118.

Brode, J. 1995. Status review of the southern torrent salamander (*Rhyacotriton variegatus*) in California. Calif. Department of Fish and Game Report, Rancho Cordova, CA. 23 pp.

Brosofske, K. B., J. Chen, R. J. Naiman, and J F. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological Applications 7(4):1188-1200.

Brown, H. A. 1975. Temperature and development of the tailed frog, *Ascaphus truei*. Comp. Biochem. Physiol. 50A:397-405.

Buhlman, K. A. 1995. Habitat use, terrestrial movements, and conservation of the turtle, *Deirochelys reticulria* in Virginia. J. Herpetology 29(2):173-181.

California Department of Fish and Game. 1995. Literature review of later-seral wildlife habitats retention. 29 pp.

Cederholm, C.J., D. B. Houston, D. L. Cole, and W. J. Scarlett. 1989. Fate of coho salmon (*Oncorhynchus kisutch*) carcasses in spawning streams. Canadian Journal of Fisheries and Aquatic Sciences 46: 1347-1355.

Colborn, T., and C. Clement (eds.). 1992. Chemically induced alterations in sexual and functional development: the wildlife/human connection. Princton Scientific Publishing, Princton, N. J.

Colborn, T., F. S. Vom Saal, and A. M. Soto. 1993. Developmental effects of endocrine-disrupting chemicals in wildlife and humans. Environmental Health Perspectives 101(5):378-384.

Colborn, T., D. Dumanoski, and J. Myers. 1996. Our stolen future: are we threatening our fertility, intelligence, and survival? - a scientific detective story. Dutton, Inc. New York.

Corn, P. S., and R. B Bury. 1989. Logging in western Oregon: responses of headwater habitats and stream amphibians. Forest Ecology and Management 29:39-57.

Cummins, K. W. 1974. Structure and function of stream ecosystems. BioScience 24:631-641.

Dahm, C. N. 1981. Pathways and mechanisms for removal of dissolved organic carbon from leaf leachate in streams. Canadian Journal of Fisheries and Aquatic Sciences 38:68-76.

Daugherty, C. H., and A. L. Sheldon. 1982a. Age-determination, growth, and life-history of a Montana population of the tailed frog, *Ascaphus truei*. Herpetologica 38:461-468.

Daugherty, C. H., and A. L. Sheldon. 1982b. Age-specific movement patterns of the tailed frog, *Ascaphus truei*. Herpetologica 38:468-474.

Davis, D. L., H. L. Bradlow, M. Wolff, T. Woodruff, D. G. Hoel, and H. Anton-Culver. 1993. Medical hypothesis: xenoestrogens as preventable causes of breast cancer. Environmental Health Perpectives 101(5):372-377.

Diller, L. V., and R. L. Wallace. 1996. Distribution and habitat of *Rhyacotriton variegatus* on managed, young growth forests in north coastal California. J. of Herpetology 30:184-191.

Eaton, J. G., J. H. McCormick, B. E. Goodno, D. G. O'Brien, H. G. Stefany, M. Hondzo, and R. M. Scheller. 1995. A field information-based system for estimating fish temperature tolerances. Fisheries 20(4):10-18.

EPA (U. S. Environmental Protection Agency). 1997. Special report on environmental endocrine disruption: an effects assessment and analysis. Risk assessment forum. U. S. Environmental Protection Agency, EPA/630/R-96/012. Washington D. C. 116 pp.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. USDA Forest Service, Portland, Oregon.

Frissell, C. A., W. J. Liss, R. E. Gresswell, R. K. Nawa, and J. L. Ebersole. 1997. A resource in crisis: changing the measure of salmon management. Pages 411-444 *in:* D. J. Stouder, P. A. Bisson, and R. J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman and Hall, New York.

Franklin, J. F. And seven others. 1981. Ecological characterisitics of old-growth Douglas-fir forests. U. S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. Research Note PNW-118. 58 p.

Franklin, J. F. And seven others. 1986. Interim definitions for old-growth Douglas-fir and mixed conifer forests in the Pacific Northwest and California. U. S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. Research Note PNW-447. 7 p.

Fuller, D. D., and A. J. Lind. 1992. Implications of fish habitat improvement structures for other stream vertebrates. Pages 96-104 *in*: R. Harris and D. Erman, eds. Proceedings of the symposium on biodiversity in Northwestern California. Report 29, Wildland Resource Center, University of California, Berkeley, CA.

Furniss, M. J., T. D. Roelofs, and C. E. Yee. 1991. Road construction and maintenance. American Fisheries Society Special Publication 19.

Gates, D. M. 1993. Climate change and its biological consequences. Sinauer Associates, Sunderland, MA. 280 p.

Good, D. A., and D. B. Wake. 1992. Geographic variation and speciation in the torrent salamanders of the genus *Rhyacotriton* (Caudata: Rhyacotritonidae). Univ. Calif. Publ. Zool. 126. 91 pp.

Gregory, S. V., G. A. Lamberti, and K. M. S. Moore. 1989. Influence of valley floor landforms on stream ecosytems. Pages 3-9 *in:* D. L. Abell, editor. Proceedings of the California Riparian Systems Conference: protection, management, and restoration for the 1990's. 1988 September 22-24; Davis, CA. General Technical Report PSW-110 Berkeley, California. Pacific Southwest Forest and Range Experiment Station. USDA Forest Service.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience 41(8):540-551.

Gulve, P. 1994. Distribution and extinction patterns within a northern metapopulation of the pool frog, *Rana lessonae*. Ecology 75(5):1357-1367.

Hall, R. J., and P. F. Henry. 1992. Review: assessing effects of pesticides on amphibians and reptiles: status and needs. Herpetological Journal 2:65-71.

Hansen, A. J., T. A. Spies, F. J. Swanson, and J. L. Ohmann. 1991. Conserving biodiversity in managed forests; lessons from natural forests. Bioscience 41(6):382-392.

Harris, L. D. 1984. The fragmented forest. University of Chicago Press, Chicago. 221 pp.

Hayes, M. P., and M. R. Jennings. 1986. Decline of ranid frogs species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? Journal of Herpetology 20(4):490-509.

Hicks , B. J., J. D. Hall, P. A. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat changes. American Fisheries Society Special Publication 19:483-5118.

Holland, D. C., and R. B. Bury. *In press*. *Clemmys marmorata* (Baird and Girard 1852) western pond turtle. In: P. C. Pritchard and A. G. Rhodin, editors. Conservation biology of freshwater turtles, volume 2.

Holt, R. D., and M. S. Gaines. 1992. Analysis of adaptation in heterogeneous landscapes: the manifold role of habitat selection. Evolution and Ecology 1992:433-447.

Huey, R. B. 1991. Physiological consequences of habitat selection. American Naturalist 137(supplement):S90-S115.

Kareiva, P., and U. Wennergren. 1995. Connecting landscape patterns to ecosystem processes. Nature 373:299-302.

Karraker, N. E., and G. S. Beyersdorf. 1997. A tailed frog (*Ascaphus truei*) nest site in northwestern California. Northwestern Naturalist 78:110-111.

Keller, E. A., A. MacDonald, T. Tally, and N. J. Merrit. 1995. Effects of large organic debris on channel morphology and sediment storage in selected tributaries of Redwood Creek, Northwestern California. Pp. 1-29, *in*: Nolan, K. M., H. M. Kelsey, and D. C. Marron, eds. Geomorphic processes and aquatic habitats in the Redwood Creek basin, northwestern California. U. S. Geol. Surv. Prof. Pap. 1454-P.

Laurance, W. F., and E. Yensen. 1990. Predicting the impacts of edge effects in fragmented habitats. Biological Conservation 55:77-92.

Lear, J. S., and C. B. Chapman. 1994. Environmental monitoring and assessment program (EMAP) cumulative bibliography. EPA/620/R-94/024. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Ledwith, T. 1996. The effects of buffer strip width on air temperature and relative humidity on a stream riparian zone. Watershed Management Council Networker 6(4):6-7.

Leonard, W. P, H. A. Brown, L. L. C. Jones, K. R. McAllister, and R. M. Storm. 1993. Amphibians of Washington and Oregon. Seattle Audubon Society, Seattle, Wash. 168 pp.

Lewis, J. 1998. Evaluating the impacts of logging activities on erosion and suspended sediment transport in the Caspar Creek Watersheds. Pp. 59-74 *in*: Ziemer, R., ed. Proceedings of the conference on coastal watersheds: the Caspar Creek story. USDA FS PS-GTR 165.

Lind, A. J., H. H. Welsh, Jr., and R. A. Wilson. 1996. The effects of a dam on breeding habitat and egg survival of the foothill yellow-legged frog (*Rana boylii*). Herpetological Review 27:62-67.

Lisle, T. E., and M. B. Napolitano. 1998. Effects of recent logging on the main channel of North Fork Caspar Creek. Pp. 87-93 *in*: Ziemer, R., ed. Proceedings of the conference on coastal watersheds: the Caspar Creek story. USDA FS PS-GTR 165.

Magnuson, J. J., L. B. Crowder, P. A. Medvick. 1979. Temperature as an ecological resource. American Zoologist 19:331-343.

Maser, C., R. F. Tarrant, J. M. Trappe, and J. F. Franklin. 1988. From the forest to the sea: a story of fallen trees. USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR. General Technical Report PNW-GTR-229, 153 p.

Mattole Sensitive Watershed Group. 1996. A nomination from concerned citizens of the Mattole River Watershed of the State of California proposing the Mattole River as a sensitive watershed. Prepared for the California Board of Forestry and the California Department of Forestry, Sacramento, California. 93 pp.

May, R. M. 1994. The effects of spatial scale on ecological questions and answers. Pp.1-17, in: P. J. Edwards, R. M. May, and N. R. Webb, eds. Large-scale ecology and conservation biology. Blackwell Scientific, Oxford, U. K.

Mayer, K. E., and W. F. Laudenslayer. 1988. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection. Sacramento, California. 166 p.

Meehan, W R., ed. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Metter, D., and R. J. Paukin. 1969. An analysis of the reduction of gene flow in *Ascaphus truei* in the Northwest U. S. since the PlEIS/EIRtocene. Copeia 1967:634-469.

Minshall, G. W., K. W. Cummins, R. C. Petersen, C. E. Cushing, D. A. Bruns, J. R. Sedell, and R. L. Vannote. 1985. Developments in stream ecosystem theory. Canadian Journal of Fisheries and Aquatic Sciences 42: 1045-1055.

Minshall, G. W., R. C. Peterson, K. W. Cummins, T. L. Bott, J. R. Sedell, C. E. Cushing, and R. L. Vannote. 1983. Interbiome comparison of ecosystem dynamics. Ecological Monographs 51:1-25.

Minshall, G. W., R. C. Peterson, T. L. Bott, C. E. Cushing, K. W. Cummins, R. L. Vannote, and J. R. Sedell. 1992. Stream ecosystem dynamics of the Salmon River, Idaho: an 8th-order system. J. N. Benthol. Soc. 11(2):111-137.

Moir, W. H. 1992. Ecological concepts in old-growth definition. Pp. 18-23, in: M. Kaufmann, W. Moir, and R. Bassett, Old-growth forests in the Southwest and Rocky Mountain Regions. USDA Forest Service, General Technical Report RM-213.

Moyle, P. B. 1976. Inland fishes of California. University of California Press. Berkeley, Los Angeles, London.

MRC (Mattole Restoration Council). 1988. Distribution of old-growth coniferous forests in the Mattole watershed: 1947 compared with 1988. Published as a poster by MRC, Petrolia, CA.

MRC (Mattole Restoration Council). 1989. Elements of Recovery: an inventory of upslope sources of sedimentation in the Mattole River watershed. Report prepared by the MRC for the California Department of Fish and Game, Sacramento, California. 47 pp.

Mulder, B.S., B.R. Noon, T.A. Spies, M.G. Raphael and others. 1997. The strategy and design of the effectiveness monitoring program for the Northwest Forest Plan. Final Report to Intergovernmental Advisory Committee and Regional Interagency Executive Committee.

Murphy, M. L. and W. R. Meehan. 1991. Stream ecosystems. American Fisheries Society Special Publication 19: 17-46.

Naiman, R. J., T. J. Beechie, L. E. Benda, D. R. Berg, P. A. Bisson, L. H. McDonald, M. D. O'Connor, P. L. Olson, and E. A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion. Pages 127-188 *in:* R. J. Naiman, editor. Watershed Management: balancing sustainability and environmental change. Springer-Verlag. New York.

Naiman, R. J., and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Reviews of Ecology & Systematics 28: 621-658.

Nakamoto, R. J. 1998. Effects of timber harvest on aquatic vertebrates and habitat in the North Fork Caspar Creek. Pp. 95-104 *in*: Ziemer, R., ed. Proceedings of the conference on coastal watersheds: the Caspar Creek story. USDA FS PS-GTR 165.

Napolitano, M. 1998. Persistence of historical logging impacts on channel form in mainstem North Fork Caspar Creek. Pp. 105-109 *in*: Ziemer, R., ed. Proceedings of the conference on coastal watersheds: the Caspar Creek story. USDA FS PS-GTR 165.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington D.C.

Nussbaum, R. A. 1969. The nest of the Olympic salamander, *Rhyacotriton olympicus*. Herpetologica 25:277-278.

Nussbaum, R. A., E. D. Brodie, Jr., R. M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University of Idaho, Moscow, Idaho.

Orians, G. H. 1993. Endangered at what level? Ecological Applications 3(2):206-208.

Reese, D. A., and H. H. Welsh, Jr. 1997. Utilization of terrestrial habitat by western pond turtles (*Clemmys marmorata*): implications for management. Pp. 352-357 *in:* J. Van Abbema, ed. Proceedings: conservation, restoration, and management of tortoises and turtles - an international conference. New York Turtle and Tortoise Society, New York.

Reese, D A., and H. H. Welsh, Jr. 1998. Habitat use by western pond turtles in the Trinity River, California. Journal of Wildlife Management 62(3):842-853.

Reese, D A., and H. H. Welsh, Jr. *In press* (1998). Comparative demography of *Clemmys marmorata* populations in the Trinity River of California in the context of dam-induced alterations. Journal of Herpetology 32(4):505-515.

Reeves, G. H., L. E. Benda, K. M. Burnett, P. A. Bisson, and J. R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring fresh-water hatitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium 17: 334-349.

Reeves, G. H., F. H. Everest, and J. R. Sedell. 1993. Diversity of juvenile salmonid assemblages in coastal Oregon basins with different levels of timber harvest. Trans. Amer. Fisheries Soc. 122(3):309-317.

Reid, L. M. 1998. Cumulative watershed effects and watershed analysis. Pp. 476-501, *In*: R. J. Naiman and R. E. Bilby (eds.). River ecology and management: Lessons from the Pacific coastal ecosregion. Springer-Verlag, New York.

Reid, L. M., and S. Hilton. 1998. Buffering the buffer. Pp. 75-85 *in*: Ziemer, R., ed. Proceedings of the conference on coastal watersheds: the Caspar Creek story. USDA FS PS-GTR 165.

Resh, V. H., and nine coauthors. 1988. The role of disturbance in stream ecology. Jour. North American Benthological Society 7:433-455.

Roper, B. R., J. J. Dose, and J. E. Williams. 1997. Stream restoration: is fisheries biology enough? Fisheries 22(5):6-11.

Ruggiero, L. F., K. B. Aubry, R. S. Holthausen, J. W. Thomas, B. G. Marcot, and E. C. Meslow. 1988. Ecological dependency: the concept and its implications for research and management. Transactions of the 53rd North American Wildlife and Natural Resources Conference, pp 115-126.

SAT (Scientific Analysis Team). 1993. Viability assessments and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest. USDA Forest Service, Washington D. C. 530 pp.

Saunders, D. A., R. J. Hobbs, C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32

Schlosser, I. J. 1991. Stream fish ecology: a landscape perspective. BioScience 41: 704-712.

Sedell, J. R., P. A. Bisson, F. J. Swanson, and S. V. Gregory. 1988. What we know about large trees that fall into streams and rivers. Pp. 47-81, in: Maser, C., R. F. Tarrant, J. M. Trappe, and J. F. Franklin, eds. From the forest to the sea: a story of fallen trees. USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR. General Technical Report PNW-GTR-229, 153 p.

Sedell, J. R., G. H. Reeves, and K. M. Burnett. 1994. Development and evaluation of aquatic conservation strategies. Journal of Forestry 92(4): 28-31.

Sedell, J. R., G. H. Reeves, and P. A. Bisson. 1997. Habitat policy for salmon in the Pacific Northwest. Pages 375- 387 *in:* D. J. Stouder, P. A. Bisson, and R. J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman and Hall, New York

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12(5):1113-1119.

Slatkin, M. 1987. Gene flow and the geographic structure of natural populations. Science 236:787-792.

Southwood, T. R. E. 1977. Habitat, the templet for ecological strategies? Journal of Animal Ecology 46:337-365.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, Oregon.

Steventon, J. D., L. Dupuis, and P. Friele. 1996. Riparian management and the tailed frog in northern coastal forests. B. C. Forest Service Extension Note No. 15. Prince Rupert Forest Region, Smithers, B. C.

Stanford, J. A., and J. V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. Pages 91-124 *in:* R. J. Naiman, editor. Watershed management: balancing sustainability and environmental change. Springer-Verlag. New York.

Stouder, D. J., P. A. Bisson, and R. J. Naiman, editors. 1997. Pacific salmon and their ecosystems. Chapman & Hall, New York. 685 pp.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Trans. Amer. Geophysical Union 38(6):913-920.

Tilman, D., R. M. May, C. L. Lehman, and M. A. Nowak. 1994. Habitat destruction and the extinction debt. Nature 371:65-66.

Townsend, C. R. 1989. The patch dynamics concept of stream community ecology. Journal of the North American Benthological Society 8:36-50.

Vannote, R. L., G. W. Minshall, G. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Jour. of Fisheries and Aquatic Sciences 37:130-137.

Walters, C. 1986. Adaptive Management of Renewable Resources. MacMillan Publishing Company, New York. 374pp.

Welsh, H. H., Jr. 1990. Relictual amphibians and old-growth forests. Conser. Biol. 4:309-319.

Welsh, H. H., Jr. 1993. A hierarchical analysis of the niche relationships of four amphibians from forested habitats of northwestern California. Ph.D. dissertation. Univ. of California, Berkeley.

Welsh, H. H., Jr., and A. J. Lind. 1992. Population ecology of two relictual salamanders from the Klamath Mountains of northwestern California. Pp. 419-437, in: McCullough, D. R., and R. H. Barrett, eds. Wildlife 2001: populations. Elsevier Science Publishers, Ltd. London.

Welsh, H. H., Jr. and A. J. Lind. 1996. Habitat correlates of the southern torrent salamander (*Rhyacotriton variegatus*) (Caudata: Rhyacotritonidae) in northwestern California. J. Herpetology 30:385-398.

Welsh, H. H, Jr., and A. J. Lind. *In Review*. The stream amphibian assemblage of the mixed conifer-hardwood forests of northwestern California and southwestern Oregon: relationships with forest and stream environments.

Welsh, H. H., Jr., and L. M. Ollivier. *In press* (1998). Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. Ecological Applications.

Wildlife/Science Committee. 1994. Approaches to wildlife cumulative-effects assessment and analysis. Report to the California Board of Forestry, Sacamento. 13 pp.

Wootton, J. T., M. S. Parker, and M. E. Power. 1996. Effects of disturbance on river food webs. Science 273: 1558-1561

Wroble, J. and D. Waters. 1989. Summary of tailed frog (*Ascaphus truei*) and Olympic salamander (*Rhyacotriton olympicus variegatus*) stream surveys for the Pacific Lumber Company, October 1987 to September 1988. Report submited to Pacific Lumber Co., 9 Jan 1989.

Yahner, R. H. 1988. Changes in wildlife communities near edges. Conservation Biology 2:333-339.

Yount, J. D., and G. J. Niemi. 1990. Recovery of lotic communities and ecosystems from disturbance--a narrative review of case studies. Environmental Management 14:547-570.

Ziemer, R., (ed.). 1998. Proceedings of the conference on coastal watersheds: the Caspar Creek story. USDA FS PS-GTR 165.

Zweifel, R. G. 1955. Ecology, distribution, and systematics of frogs of the *Rana boylii* group. Univ. Calif. Publ. Zool. 54:207-292.